JULY, 1931 NUMBER 274

THE UNIVERSITY OF NORTH CAROLINA RECORD

THE SCHOOL OF ENGINEERING

CATALOGUE ISSUE 1930-1931

Announcements for the Sessions

1931-1932 and 1932-1933

THE UNIVERSITY OF NORTH CAROLINA PRESS
ISSUED IN OCTOBER, DECEMBER, MARCH, APRIL, MAY, JUNE, AND JULY
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CATALOGUE OF EVENTS

1931

June 6-9	*Saturday through Tuesday.* Commencement exercises.
June 11-July 21	Summer session, first term.
July 22-August 28	Summer session, second term.
Sept. 9-12	*Wednesday through Saturday.* Entrance examinations and examinations to remove conditions.
Sept. 14	Coöperative Section II goes to work.
Sept. 15-17	*Tuesday through Thursday.* Freshman week.
Sept. 16	*Wednesday.* Registration of freshmen for the fall quarter.
Sept. 17.	*Thursday.* Registration (all except freshmen) for the fall quarter.
Sept. 18	*Friday.* Class work for the fall quarter begins.
Nov. 25	*Wednesday.* Thanksgiving recess begins (1:00 P.M.).
Nov. 30	*Monday.* Thanksgiving recess ends (8:30 A.M.).
Dec. 16-19	*Wednesday through Saturday.* Examinations for the fall quarter. Registration (for the winter quarter) of all except freshmen and sophomores.
Dec. 19 (afternoon)-Dec. 31, 1931	Christmas recess.
Dec. 28, 1931	Coöperative sections change.

1932

Jan. 1	*Friday.* Registration (freshmen, sophomores, and new students) for the winter quarter.
Jan. 2	*Saturday.* Class work for the winter quarter begins. Regular classes as of Thursday. Coöperative Section II goes to school.
Mar. 9-12	*Wednesday through Saturday.* Examinations for the winter quarter. Registration (for the spring quarter) of all except freshmen and sophomores.
Mar. 12-18	*Saturday afternoon through Friday.* Spring recess.
Mar. 19	*Saturday.* Registration (freshmen, sophomores, and new students) for the spring quarter.
Mar. 21	*Monday.* Class work for the spring quarter begins. Coöperative sections change.
May 30-June 2	*Monday through Thursday.* Examinations for the spring quarter.
June 4-7	*Saturday through Tuesday.* Commencement exercises.

For 1932-33 Catalogue of Events, see later announcement.

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THE SCHOOL OF ENGINEERING

Introductory Statement

When the University of North Carolina opened its portals in 1795, the first student to seek admission was Hinton James of Wilmington, who, after a distinguished career as a student, engaged in the practice of engineering. Thus, from its very foundation the University of North Carolina has afforded training for engineers.

It is recorded of this first student that his college productions included essays on such diverse subjects as "The Uses of the Sun," "The Motions of the Earth," "The Commerce of Britain," and "The Effects of Climate on the Minds and Bodies of Men." This catholicity of interest, ranging from astronomy to commerce, was a remarkable forerunner of the present engineering curriculum, which includes many subjects remote from strictly technical applications, but which is designed to produce broad-visioned leaders in the constructive development of the state's resources, who may worthily follow the tradition of engineering service so strikingly inaugurated by the first student at the University.

After graduating, James was in charge of channel improvements on the Cape Fear River, among the first improvements to inland waterways to be undertaken in this state. The remains of certain dikes constructed by him are visible today, structures which have persisted in spite of one hundred and forty years of river floods and deposits.

Engineering courses were offered at the University as far back as 1852 when Charles Phillips was made Professor of Civil Engineering, the Department of Civil Engineering being included in the "School for the Application of Science to the Arts." This arrangement continued until the University was closed in 1868. In the first year after the re-opening, 1875-1876, the College of Engineering is listed in the catalogue with an outline of the course of study covering three years. In 1888-1889 Engineering and Mathematics were united under one department, but when the Department of Applied Science was formed in 1904-1905 the engineering courses were included in it. The Department of Applied Science became the School of Applied Sciences in 1907-1908 and the departments of Chemical, Civil, and Mining Engineering, and Soil Investigation are listed as parts of this School of Applied Sciences in the catalogue of 1909-1910. The departments of Engineering continued under the School of Applied Sciences until June, 1922, when the School of Engineering was authorized. The School of Engineering now consists of the three departments of Civil, Electrical, and Mechanical Engineering, and also offers a curriculum in Chemical Engineering.

The material and industrial growth of the South is proceeding at such a rate as to require increasing numbers of men trained in design, construction, and administration relating to the control of

the great forces of nature for the use and convenience of man. The great highway systems springing into being throughout the South; the new sky-scrapers, office buildings and hotels; the municipal systems of water supply, sewerage, and paving; the public health and agricultural aspects of drainage; the utilization of rivers for navigation and water power; the generation, transmission, distribution, and utilization of electric energy—all these are making unprecedented demands upon technically trained men, not only for designing and constructing but also for operation and administration.

The engineer of today, and of the future, will not only be called upon to contribute in a large measure to the direction of the material welfare of the human race, but also will be concerned greatly with the management of men, and will be selected more and more to fill places requiring much administrative and executive training.

It is becoming generally recognized by engineering educators and by others who are seriously concerned with the training of engineering students that there is a growing tendency to crowd the curriculum with purely technical subjects, thereby neglecting the broader cultural side which is essential in the training of any professional man and which particularly applies to the engineer. The engineering courses, therefore, have been developed along broad and cultural lines, and the necessity for cultural training as a part of a thorough technical education has been kept constantly in mind. The importance of English in the curricula has been emphasized. The courses have been arranged so that the students will receive instruction in English throughout the four-year period. Much attention is also given to training in public speaking. This is an acquired art, and a very necessary adjunct of an engineering education. Engineers must be versed in business affairs. To meet this condition students devote considerable time to economics and business administration and management. During the first three years, the contents of the curricula are practically the same for all engineering students. Fundamentals in mathematics, mechanics, and other sciences are contained in these first three years, and the application of these fundamentals is illustrated throughout the courses by the solution of practical problems in engineering.

For those whose abilities, inclinations, and opportunities permit intensive training in special branches of engineering the fifth or graduate year has been designed. Especial attention is called to the provisions for graduate study described on pages 32-33. The courses required for a graduate degree in the several special branches of engineering are stated on pages 35-40, and the detailed descriptions are to be found on pages 41-56.

In order to accommodate the growing number of students who prefer to take two or more years of preliminary education in a liberal arts college, the faculty suggests that certain fundamental courses contained in the freshman and sophomore years of the

engineering program be included in the courses taken in the liberal arts college. These courses, when submitted for credit, will enable the applicants for the engineering degree to complete the course of study in the School of Engineering of the University in three years. This pre-engineering schedule may be taken at any accredited liberal arts college or in the College of Liberal Arts of the University. For a detailed outline of the suggested courses see pages 33-35.

The intimate contact of engineering students with the academic students affords excellent opportunity for all-round cultural training. Since the School of Engineering is an integral part of the University of North Carolina, which is a member of the Association of American Universities, it is of significant importance that young men who wish to pursue a training in engineering are also afforded the opportunity of registering as students in a university embracing a strong liberal arts college and of thereby reaping the advantages of this cultural association.

COÖPERATIVE ENGINEERING EDUCATION

For the past twenty years or more a great amount of time and thought has been devoted to engineering by engineering teachers and the profession at large with the idea in mind of adopting some method in engineering education which would develop the observation and initiative of the students and bring them in touch with outside things during their theoretical training. Criticism has often been directed by practising engineers against young engineering graduates that they did not have any grasp or conception of practical things after four or five years of theoretical training.

In order to meet this criticism, the University of Cincinnati installed in the fall of 1906 a method of engineering education which is called coöperative education. Under this plan the students spend half of their time at the University receiving their theoretical training and the other half with engineering or industrial firms, thus securing some practical training during their collegiate period. This system of education has proven quite successful and has been adopted by a number of prominent institutions, among which are Massachusetts Institute of Technology, the University of Pittsburgh, and New York University. The method of coöperation has been modified by several of the institutions that have adopted this system; for example, a plan has been arranged whereby only the junior class coöperates with the outside industries. This modified plan permits the students to get that touch with outside practice, but does not destroy the social and cultural contact which they derive from full-time association on the University campus during the freshman, sophomore, and senior years.

Realizing that the coöperative system of training young engineers is a distinct step forward, the School of Engineering at the University of North Carolina adopted this plan of education in September, 1922.

Under this plan the students of the junior class, except those studying chemical engineering, are divided into two groups designated as sections I and II. The students in each group spend half their time at the University and the other half in actual engineering work. Each student has an alternate, so that when a student of section I is at school his alternate in section II is on the job. At definite intervals the student from section II goes to school while his alternate in section I takes his place on the job. This alternation continues throughout the junior year up to the latter part of September. Both sections attend the University full time during their senior year.

In order to compensate for the time that the students are away from school during the junior year, instruction is given to all engineering students for a period of twelve weeks in the summer following the sophomore year, and for twelve weeks in the summer following the junior year to coöperative section II. Under this plan the students receive the same amount of school work as under the conventional four-year plan. The students receive pay for their services during the time that they are engaged in their outside work, thus enabling them partially to defray their expenses during their junior year.

Students in chemical engineering spend the junior year in residence. In lieu of coöperative work, they are expected to work for one summer in the plant of a chemical industry. The University will assist as far as possible in securing such summer positions.

During the past ten years the school has enjoyed a most cordial and satisfactory coöperative relationship with the following organizations: Duke Power Company; Tidewater Power and Light Co.; Caterpillar Tractor Co.; Carolina Power and Light Co.; Southern Railway System—Signal Department, and Maintenance of Way Department; R. H. Bouligny, Inc.; Armature Winding Co.; North Carolina State Highway Commission—Location Department, Bridge Department, Testing Department, and Fourth District Engineer's Office; City of Charlotte; City of Tarboro; University Consolidated Service Plants; U. S. District Engineer's Office; Atlantic Gas Co.; Durham Public Service Co.; Carolina Engineering & Heating Co.; Town of Chapel Hill; University of North Carolina; Mooresville Water Works; Western Electric Co.; N. C. Department of Conservation and Development; N. C. State Board of Health.

COÖPERATION WITH NATIONAL ENGINEERING SOCIETIES

Four national professional societies—the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Institute of Chemical Engineers—have established student chapters in the School of Engineering. Through these societies the students are given opportunities for social intercourse, the presentation of

papers, and the development of the art of self-expression. They bring to the University each year many men of national reputation to discuss the developments and accomplishments of modern engineering.

THE ENGINEERING LABORATORIES

A marked characteristic of the school is its well-equipped laboratories, which are housed in Phillips Hall and include the facilities of Venable Hall.

Laboratory instruction is recognized as an important element of an engineering education, and with the excellent laboratory facilities the students study the fundamental laws of engineering.

The following descriptions indicate the major equipment of the engineering laboratories.

Materials Testing Laboratory

The materials testing laboratory is equipped with a 100,000-pound Riehlé Universal testing machine and a 200,000-pound Olsen machine, both of which are used in tensile, compressive, and transverse tests of all important structural materials. Special features of these machines make possible the testing of long columns and beams and the cold bend test of metals.

Numerous smaller pieces of apparatus are provided for studying the elastic properties of materials; annealing and tempering of metals; fire resistance of stone and clay products; hardness of materials; shearing strength of timber, etc.

A complete set of apparatus for making all the standard tests of cement, and miscellaneous equipment for routine tests or research work on sand, coarse aggregate, mortar, and concrete, are in use.

Civil Engineering Laboratories

The highway engineering laboratory is equipped with apparatus for the standard tests of bituminous and non-bituminous road materials, consisting in part as follows: Engler viscosimeter, penetrometer, ring and ball melting-point apparatus, open cup oil tester, New York Board of Health oil tester, Hubbard-Carmick specific gravity flask, hydrometers, float testing apparatus, constant temperature and drying oven, ductility machine, Dulin rotarex, Deval 4-cylinder abrasion machine, diamond core drill, diamond saw, grinding lap, Page impact, ball mill, briquette former, cementation machine, etc.

The hydraulic laboratory occupies a separate building adjacent to Phillips Hall. It is equipped with apparatus to show the phenomena of flow of water in pipes, including hydraulic gradient, friction loss, venturi effects, pitometer traverses, etc. Large orifice and weir tanks provide opportunity for experiments on the dis-

charge of water through these measuring devices. Facilities are also available for experiments on friction loss and discharge through hydrants, pipe lines, and nozzles, the testing of meters, the determination of total pressures on submerged areas, etc. Measuring tanks are provided, of sufficient capacity to make practical demonstrations of hydraulic phenomena occurring in practice and to permit of research on hydraulic problems.

A model gauging station of the standard type of the U. S. Geological Survey has been installed on Morgan's Creek, the source of the University water supply. This is equipped with an Au water-stage register. Students are given practical experience in stream gauging, and a part of the laboratory instruction includes also the making of meteorological observations at the U. S. Weather Bureau rainfall and evaporation station located on the campus.

The new laboratories of sanitary engineering are located in the building of the University water purification plant, in a wing of Phillips Hall. They comprise: a biological room equipped for microscopic and bacteriological work, which also contains plan files and an extensive reference library of sanitary engineering literature, making it suitable for seminar, laboratory, and reference purposes; a chemical laboratory with equipment for conducting any of the determinations ordinarily required in sanitary chemistry; a preparation room for the cleansing and sterilization of glass ware and the preparation of reagents and culture media; a dark room for ultramicroscopic, photomicrographic, and turbidimetric work, a chemical storage and balance room, a private laboratory; and a research laboratory for the use of graduate students doing special work.

These laboratories are well equipped with apparatus for carrying on the usual physical, chemical, and biological analyses of gases, milk, water, sewage, and industrial wastes, for the testing of sands and other materials used in sanitary engineering works, for studies of corrosion, for limnological and stream-pollution investigations, and for experimental and research work in the field of sanitary engineering. The water filtration plant is used for demonstration and experimental purposes in the study of problems of water purification; three types of sewage treatment plants located in town afford an opportunity for the study of waste treatment and stream pollution; and nearby towns with excellent sanitary plants coöperate with the School in providing facilities for the investigation of the various problems of municipal and public health engineering.

The surveying laboratory equipment comprises a number of transits, levels, plane tables and auxiliary instruments, such as level rods, chains, range poles, stadia rods, Locke levels, telescopic alidades, barometer, etc. Enough instruments are furnished so that each student will receive a maximum of practice. All the modern types of instruments are represented so that the student may become familiar with the different manufacturers' products.

Electrical Engineering Laboratories

The electrical engineering laboratories consist of a large dynamo laboratory, having over three thousand square feet of floor space on the ground floor of the main section of Phillips Hall, and seven special laboratories on the second floor of the west wing. They are all supplied with power through a seven-panel slate switchboard in the main laboratory, which feeds twenty distribution panels in the different laboratories. Most of the sub-panels are connected with the main board by ten wires and a plug and socket system which makes it possible to supply any of the laboratories with several different kinds of power at the same time. The main power supply consists of a 25-kw., 125-volt direct current motor-generator set; a 5-kw., 6- or 12-volt electrolytic type motor-generator, and three-phase, 110- and 220-volt circuits of 25-kw. each. There is also available a 4-kw., three-phase alternator having a practically pure sine wave for use in iron testing.

The dynamo laboratory contains some forty machines, mostly of modern design, including a 15-kv.a. General Electric motor-generator set, with revolving field alternator, wound for single-, two-, three-, or six-phase; two 5-kv.a. Westinghouse M. G. sets; two 10-kw. synchronous converters; two 5-kw., and two 3-kw. direct current M. G. sets; a 3 h.p. General Electric Type RF variable speed motor with compensating winding in the pole faces; a 5-h.p. General Electric three-phase induction motor with wound rotor and drum type controller; a 3-h.p. General Electric Type RI repulsion motor, and a number of other machines ranging from two to ten horsepower.

A mezzanine gallery at one end of the laboratory contains a 50,000-volt and a 10,000-volt testing transformer, a number of distribution and laboratory type transformers, as well as a 50-ampere General Electric mercury arc rectifier.

More than one hundred and fifty portable ammeters, voltmeters, and wattmeters are available for routine testing.

Standardization laboratory. A special laboratory for the standardization of instruments contains the following precision laboratory standards: A 150-volt Weston d.c. voltmeter, a millivoltmeter with complete set of shunts up to 1,000 amperes capacity, a 5-10-ampere Westinghouse Kelvin-balance type ammeter, and 200-ampere, 300-volt Kelvin-balance type wattmeter, and a 150-ampere, 440-volt, three-phase States test table for checking watthour-meters with General Electric and Westinghouse rotating standards. The precision instruments are mounted on 24 x 48-inch slate table tops set in concrete piers, and each test station is permanently wired with all the necessary control equipment so the calibration of any instrument may be quickly checked.

The photometric laboratory is equipped with a standard Reichs-

anstalt photometer bench with three-meter track equipped with standard track screens for daylight work, Bunsen screen, Lummer-Brodhun disappearance and contrast screens, standard Hefner lamp, a number of certified carbon and tungsten incandescent standards, a compound rotator, a luxometer, a General Electric foot-candle meter, a Macbeth illuminometer for illumination surveys, and a number of shades and reflectors of various types. The laboratory has recently acquired a Leeds and Northrup flicker photometer for comparing lights of different colors.

Freshman laboratory. A special feature of the instruction in electrical engineering at the University is the freshmen course. The student begins his study of the basic principles of the electrical engineering profession at the beginning of the freshman year. The lectures, reading, and assigned problems are accompanied by work in a specially equipped laboratory. Here standard electrical engineering equipment is used in illustrating the fundamental principles of electricity. Various exhibits donated by the manufacturers illustrate the constructional details and manufacturing processes of electrical apparatus and supplies. During the course each individual is studied with a view to guiding his future work into channels for which he is obviously best fitted.

Telephone and radio laboratory. A special laboratory is equipped for work in telephone transmission and radio-frequency measurements. There is available a variety of standard telephone equipment including transmitters, receivers, repeating coils, etc., and a 32-mile standard artificial line.

The facilities for radio measurements include General Radio Company decade and capacity bridges, precision wave-meters, precision condensers, and low frequency oscillators. There is the usual complement of coils, condensers, variometers, hot-wire and thermo-couple meters, and practically all types of vacuum tubes. Receiving sets of all types, from the simple regenerative circuit to the most complicated superheterodyne, are available for reception in the broadcast range.

Radio Station W4WE. A separate room is provided for the radio station operated by the department under the call letters W4WE. This station, which is an official relay station of the American Radio Relay League, has been operating for several years with a 50-watt transmitter on the 40-meter wave band, and during this time the station has been in communication with all continents. Two more transmitters are also in service, a 100-watt set for both code and radiophone on the 150-200-meter band, and a 50-watt set for the 80-meter band. With these sets, communication can be had with any part of the United States and most foreign countries.

Measurements laboratory. For work in electric and magnetic measurements there is a large laboratory equipped with several bridge testing sets, a Kelvin double-bridge, Queen-Gray potentio-

meter, capacity bridge, Leeds and Northrup ballistic and D'Arsonval galvanometers of high sensitivity, and precision standards of resistance, inductance, and capacity. There is also a standard Epstein apparatus for the measurement of iron losses.

Research laboratory. A separate room is equipped for the study of special research problems. It contains a complete General Electric oscillograph and has a small dark room for photographic work.

Mechanical Engineering Laboratories and the Power Plant

The mechanical engineering laboratories are located on the ground floor of the new wing of Phillips Hall, the main laboratory occupying the greater part of this floor.

The principal laboratory is equipped for making experimental studies of power plant apparatus. It contains a 10-inch by 15-inch Fitchburg uniflow steam engine especially equipped with indicator reducing motion, brake wheel with prony brake, special facilities for cutting in and out of jackets, and hand regulated auxiliary exhaust valves for operation from a 26-inch vacuum up to 10-pound back pressure. It contains, also, a 25-kilowatt, 250-volt direct current General Electric turbo-generator set with switchboard and a 25-horsepower Chandler and Taylor slide valve engine especially equipped with indicator reducing motion, prony brake, surface condenser, and indicator piping for experimental work. Serving both the uniflow engine and the turbine, there is a Wheeler surface condenser capable of condensing 3,000 pounds of steam per hour.

Other equipment includes a 40-horsepower, compound marine engine, designed and built by the Bureau of Steam Engineering of the U. S. Navy, a Liberty "12" airplane engine, a Vaught airplane with a Wright "E" engine, two small gas-electric lighting units, and two variable pressure steam testing drums. Smaller equipment includes calorimeters, flow meters, thermometers, indicators, scales, dynamometers, a collection of aircraft instruments, and other accessory apparatus for making complete tests on power plant machinery.

Under a portion of the main laboratory there is a sub-basement for condensers and water measuring apparatus.

Adjoining the main laboratory there is a small laboratory for light testing work, such as calibration of instruments, flue gas analysis, fuel analysis, and fuel and oil testing. It is provided with a Parr Oxygen Bomb coal calorimeter, a Junker gas calorimeter, a Saybolt universal viscosimeter, a Hayes gas analyzer, and other instruments for analyzing and testing fuels and oils.

As a valuable aid in visual instruction and practical experience, the University Power Plant is also available for laboratory purposes. The principal equipment of the plant consists of the power boilers and generating equipment. The boiler room contains one 450-horsepower and two 168-horsepower Babcock and Wilcox boilers,

one 350-horsepower Union Iron Works boiler, a 500-horsepower Cockrane feed water heater, and large exhaust and live steam heaters for the hot water heating system of the University. The engine room contains a 750-kv.a., 2,300-volt General Electric alternator driven by a Skinner uniflow engine, and a large switchboard for controlling the electrical equipment. The pump room contains three large turbine-driven centrifugal pumps for circulating hot water through the heating system, and motor-driven service and fire pumps.

Chemical Engineering Laboratories

Venable Hall, a fireproof building constructed in 1925, houses the chemical engineering laboratories. A large laboratory of approximately 1,500 square feet floor area and 25 feet high contains the larger apparatus. The equipment includes an Oliver filter, a small plate and frame filter press, centrifuges, a paint mill, a jaw-crusher, a ball mill, a Dopp kettle with a variety of agitators, several smaller kettles, tanks, and pumps. The laboratory is fitted with a two-ton traveling crane. Adjacent are a dark-room, transformer room, storage rooms, and four control laboratories. These latter contain equipment for gas, fuel, water, and lubricant analysis. Oxygen and peroxide bomb calorimeters, a Junker gas calorimeter, moisture oven, volatile matter, ash, and ash-fusion point furnaces, flash and fire-point testers, etc., are included. A Wysor polishing machine, metallographic camera, microscopes, and furnaces are provided for work in metallography. In general, each graduate student is allotted a small private laboratory for his personal use. The library of Venable Hall is unusually rich in complete sets of bound periodicals, in addition to the usual reference works and texts.

In addition to the above, the equipment and facilities of the entire Department of Chemistry are at the disposal of the students in chemical engineering for special studies.

THE ENGINEERING LIBRARY AND READING ROOM

The engineering library and reading room is located at one end of Phillips Hall. It contains about 3,000 volumes of technical books dealing specifically with the various branches of engineering and some 3,000 volumes of bound engineering periodicals, and is very well equipped for reference and research purposes.

All of the standard engineering periodicals published in this and foreign countries are regularly received, together with numerous periodicals relating to the business and economic phases of engineering. Complete sets of such standard proceedings as those of the American Society of Civil Engineers, American Institute of Chemical Engineers, American Institute of Electrical Engineers, American Society of Mechanical Engineers, American Institute of Mining

Engineers, *Journal* of the Institution of Engineers (British), National Electric Light Association, *Journal* of the Franklin Institute, etc., are available, and the current numbers are kept on file. In addition, the scientific publications of the United States Government and of the various technical institutions and universities are regularly received.

The engineering library is constantly increasing its collection of domestic and foreign publications, and in general when special books are needed for research, or other purposes, arrangements may be made for their purchase. When rare treatises and technical publications, not generally purchasable, are desired they may be obtained by a working agreement with the Library of Congress, whereby such publications may be loaned to the engineering library.

The libraries of the departments of Physics and Mathematics are contained in the same room with the engineering library. These libraries number some 5,000 volumes, many of which are extremely rare and important foreign works. These libraries also receive the domestic and foreign periodicals devoted to physics and mathematics.

The library of the Department of Chemistry is located in Venable Hall. This library contains some 8,000 volumes, consisting of many technical books and periodicals on both pure and applied chemistry from the United States, Canada, England, France, Germany, Italy, and Austria. Ample lighting and study space are provided in this modern library.

The association of the four libraries makes an ideal working arrangement, whereby the advanced student is enabled to consult conveniently books in these allied branches of science.

ADMISSION AND OTHER INFORMATION

Admission

Admission to the University

Evidence of successful vaccination against smallpox is a prerequisite for the admission of students to this institution. Applicants for admission to any school are hereby informed that a certificate as to successful vaccination must be sent to the Dean of Admissions before they can be admitted.

Candidates for admission to the University are received by certificate from accredited schools or by examination.

Entrance by Certificate. Students who present certificates of work accomplished at preparatory schools and colleges may be admitted without examination, provided the certificates are approved. The right to examine, however, is reserved, when such a course is deemed necessary. Certificates must be made out on the printed forms furnished on application to the Dean of Admissions, and should be sent in as early as possible in the summer vacation. Notice is hereby given that satisfactory credentials must be in the hands of the Dean of Admissions before an applicant may register. Candidates must present themselves in person before the Committees on the Registration of Freshmen during the period of registration.

Entrance by Examination. The University will accept the certificates of the College Entrance Examination Board provided the applicants submit satisfactory school certificates also. Statewide entrance examinations are held, when asked for in advance, at the offices of the county superintendents early in June and at the University in the week preceding the opening of the fall quarter in September. These examinations are given to graduates of non-accredited high schools and to others who present evidence of having completed the equivalent of a four years' high school course, aggregating at least fifteen units from the subjects listed below. The Dean of Admissions in each instance must approve the applicant's record as meeting this requirement. Candidates for admission by examination in September must make application to the Dean of Admissions in writing two weeks before the date for registration. Time and place for examinations will be arranged.

Admission to Advanced Standing

A candidate may be admitted to advanced standing in accordance with the amount and character of his previous training. The Dean of Admissions will accept, with proper restrictions, an official transcript of work satisfactorily completed at a college or university of good standing. All credits allowed by him stand in suspense until the candidate shall have spent one quarter in residence. If his work

during this quarter is unsatisfactory, the credits may be cancelled.

A candidate for advanced standing must send to the Dean of Admissions his application accompanied by an official transcript of his previous record at least two weeks before the date for registration. Blank forms may be secured by writing the above officer. Notice is hereby given that applicants whose records at other institutions do not reach the standard required for the readmission of students at this institution will not be admitted. Notice is hereby given that satisfactory credentials must be in the hands of the Dean of Admissions before an applicant may register.

Admission of Women

By action of the Trustees in February, 1897, women were made eligible for admission to the Graduate School of this institution. Almost immediately this action was extended so that women were eligible for admission to the two upper classes of the college. Some years later women whose training was found to be sufficient were admitted to the professional schools of law, medicine, pharmacy, and later to courses in engineering.

Entrance Requirements

For admission to the freshman class of the University of North Carolina fifteen units secured by the completion of a four years' high school course are required. *The fifteen units must be chosen from the list printed below and in accordance with the restrictions stated in the foot-notes following that list.* The applicant must either present an official certificate showing his preparatory work and the recommendation of his *school (which must be on the list of accredited schools) or stand entrance examinations on an equivalent amount of preparatory work as provided for on the preceding page.

It must be clearly understood that admission to the University does not necessarily mean admission to candidacy for a degree.

In order for a student to be admitted to candidacy for a degree, he must meet the specific requirements laid down by the school or college in which the degree is conferred. In some cases this will make it necessary for the candidate to carry certain courses as prerequisites over and above the courses prescribed for the degree or to make up certain deficiencies. These deficiencies must be made good before the student may register for his sophomore year.

The preparatory student should decide therefore, as early as possible, for which degree he wishes to become a candidate and carry such courses in his preparatory school as will admit him to candidacy for that degree.

* It is definitely understood that, in case an applicant has attended another school subsequent to graduation from a high or preparatory school, the recommendation of the school last attended is required.

Subjects Acceptable for Entrance Credit

The complete list of subjects acceptable for entrance with the credit that may be secured in each subject is as follows:

English	4 units
*History	1 to 4 units
Mathematics	2 to 4 units
Greek	1 to 3 units
Latin	1 to 4 units
French	1 to 3 units
German	1 to 3 units
Spanish	1 to 3 units
†Biology	½ or 1 unit
†Botany	½ or 1 unit
†Chemistry	½ or 1 unit
†Physics	½ or 1 unit
†Zoölogy	½ or 1 unit
†General Science	½ or 1 unit
†Physiography	½ or 1 unit
Physiology	½ unit
Civics	½ or 1 unit
Economics	½ or 1 unit
‡Scouting	½ or 1 unit
¶Music	½ or 1 unit
‡Military Science	½ or 1 unit
°Vocational subjects	
Commercial Geography	½ unit
Drawing	½ or 1 unit
*General Agriculture	½ to 2 units
Bookkeeping	1 unit
Commercial Arithmetic	1 unit
Stenography and Typewriting	1 unit
Manual Training	½ to 2 units

Prescribed Requirements

Candidates for admission to the School of Engineering must present credit in the following subjects:

BACHELOR OF SCIENCE IN CHEMICAL, CIVIL, ELECTRICAL, AND MECHANICAL ENGINEERING

English	4 units
American History	1 unit
Mathematics (Algebra, Plane Geometry)	2½ or 3 units
French, German, Spanish, Greek, or Latin	2 units
Science	1 unit
Electives	4½ or 4 units
Total	15 units

NOTE: That the requirements for admission to candidacy for the degree S.B. in Chemical, Civil, Electrical, and Mechanical Engineering call for: *One* foreign language.

* As many as four (4) units in history and two (2) units in agriculture may be accepted. This amount of credit will be allowed only when the Dean of Admissions is satisfied that the work done in these subjects at any given school is of a superior order.

† One (1) full unit in any of the sciences will be allowed only when satisfactory work is done in the laboratory as evidenced by the notebook; otherwise only one-half (.5) unit will be allowed.

‡ Entrance credit for this subject will be allowed only in case the certifying school credits it towards its diploma.

¶ Credit for music will be allowed only in case the work is shown by a supplementary certificate to conform with the standards set up by the Association of Colleges and Secondary Schools of the Southern States and provided also the certifying school credits it towards its diploma.

° Credit for vocational subjects is limited to a total of three (3) units.

EXPENSES

The University reserves the right to make, with the approval of the proper authorities, changes in any fees at any time.

Tuition and Other Fees for Each Quarter

	Residents of N. C.	Non-Residents of N. C.
School of Engineering:		
Tuition	$ 33.34	$ 58.34
*Matriculation	14.50	14.50
Student Publications	1.66	1.66
Laundry Deposit	8.50	8.50
Total for each quarter	$ 58.00	$ 83.00

LAUNDRY DEPOSIT: Students will be required to send their washing to the University Laundry, for which a deposit will be collected at the time of registration.

LABORATORY FEES: Each student taking a laboratory course must pay, in addition to his tuition fee, a small fee for power or materials used in the laboratory. The fees for the various laboratory courses are as follows:

ENGINEERING

G.E. 36abc	$ 4.00 a quarter	G.E. 56	$ 5.00
G.E. 236abc	5.00 a quarter		
Ch.E. 94	$ 7.00	Ch.E. 191	$10.00
C.E. 25a	$ 4.00	C.E. 30a	$ 4.00
C.E. 35a	6.00	C.E. 40a	4.00
C.E. 55a	4.00	C.E. 60a	8.00
C.E. 65a	4.00	C.E. 160abc	4.00 a quarter
C.E. 165abc	4.00 a quarter	C.E. 280a	2.00
C.E. 285ab	2.00 a quarter	C.E. 290abc	5.00 a quarter
C.E. 360abc	5.00 a quarter	C.E. 365abc	5.00 a quarter
C.E. 370abc	5.00 a quarter		
E.E. 2abc	$ 4.00 a quarter	E.E. 22abc	$ 4.00 a quarter
E.E. 52bc	5.00 a quarter	E.E. 62abc	5.00 a quarter
E.E. 97abc	3.00 a quarter	E.E. 162abc	7.00 a quarter
E.E. 262a	10.00 a quarter		
M.E. 53bc	$ 5.00 a quarter	M.E. 63abc	$ 5.00 a quarter
M.E. 73a	5.00	M.E. 78c	5.00
M.E. 83a	5.00	M.E. 166a	5.00
M.E. 186bc	5.00 a quarter		

* This fee includes fee for physical education, the library fee, the fee for attendance of the University Physician, and the fee for debates.

CHEMISTRY

1-2	$ 5.50 a quarter	41, 42, 91, 92	$10.00 a quarter
61, 62	10.00 a quarter	81, 82, 185	7.00 a quarter
93	5.00	121, 122, 123	10.00 a quarter
163, 164, 165	10.00 a quarter	191, 192	10.00 a quarter
391, 392, 393	10.00 a quarter		

GEOLOGY

11, 12	$ 3.00 a quarter	43-44	$ 5.00 a quarter
77-78	3.50 a quarter		

PHYSICS

21, 22, 23E	$ 2.50 a quarter

TRANSCRIPTS OF RECORD. One transcript will be furnished without charge. Additional transcripts will be furnished only upon payment of $1.00 for each copy.

DIPLOMA. The fee for a diploma is $5.00, payable one week before the date of the award of diplomas at commencement or at the end of the Summer School.

Board

Excellent board is furnished at Swain Hall for $22.00 a month. A few students can earn their board by waiting on the tables.

Board without room can be obtained in the town from $22.50 to $35.00 a month.

Dormitory Accommodations

Accommodations for approximately fourteen hundred students are available in the University dormitories.

All rooms in the dormitories are completely furnished. Students will, however, provide their own pillows, bed linen (for single beds), and towels.

Room rent ranges from $5.00 to $11.00 a month for each occupant, the price depending upon the location of the room. This charge includes light, heat, and service.

PECUNIARY AID

Scholarships

All of the scholarships described in the general catalogue of the University are open to students in the School of Engineering.

All applications for scholarships must be filed in the President's office on or before July 1, and must be in the regular form prescribed by the University. Blank forms are supplied on application to the President.

Free Tuition

Free tuition in the School of Engineering is given to the sons of ministers residing in the state, and to residents of North Carolina under bodily infirmity.

Loan Funds

All of the loan funds of the University, amounting to several thousand dollars, are open to worthy and needy students in the School of Engineering.

THE J. E. LEAR FUND. This fund of $5,244 became available in 1924 as a fund upon which students in the School of Engineering, especially students in electrical engineering, would have first claim. The fund was the result of installation work done by the senior class in electrical engineering under the supervision of Professor J. E. Lear.

Applications for Loans

Applications for loans will be considered when made in person by students registered in the University. The funds are limited in amount and are loaned only on the security of two approved signatures and at the legal rate of interest. Application should be made to the Dean of Students as far in advance as possible.

Self-Help

It is confidently believed that no institution offers wider opportunity for self-help to meritorious students of slender means. The desire is that no worthy boy, however poor, shall ever be turned away for lack of means. To such the University and town offer unusual opportunities for support. Many students are now working their way through college by every form of honorable labor. A number are here as a result of money earned or borrowed. A few students are selected by the authorities as waiters at Swain Hall. Otherwise all opportunities available in the University and town must be secured by the personal efforts of the individual, with the assistance of the Self-Help Bureau of which Mr. Edwin Lanier is secretary. They are not assigned by the President of the University nor by the Executive Secretary nor by the Dean of Admissions nor by the Dean of Students. Application should be made to the Self-Help Bureau of the Y. M. C. A. as far in advance as possible.

REGULATIONS

Special Notice to Students

This catalogue is intended to give such a description of the work of the University and such a digest of its rules as are needed by students. Neither the courses announced nor the rules given are valid beyond

the succeeding year, for before the end of the succeeding year a new catalogue will have been issued, superseding all previous catalogues. Ordinarily a student may expect to be allowed to secure a degree in accordance with the requirements of the curriculum laid down in the catalogue in force when he first entered the University, or in any one subsequent catalogue published while he is a student; but the faculty reserves the right to make changes in curricula, as in rules, at any time when in its judgment such changes are for the best interests of the students and the University.

Freshman Week

In order to facilitate the process of adjustment which the freshman must pass through, the University has set up a "freshman week" program. The events of this week include mental and physical measurements, pre-registration counseling, special lectures on student traditions, library tours, and social gatherings, in addition to the registration for courses on Wednesday. This program begins with a meeting of the entire freshman class in Memorial Hall at 8:30 a.m. on Tuesday morning, September 15, 1931. All students entering the University for the first time in the freshman class are required to be present at this and all other appointments comprising the program of freshman week.

Registration

All students are expected to present themselves for registration *Wednesday* or *Thursday, September 16* or *17, 1931*, between the hours of 9 a.m. and 5 p.m., at the places announced in the plan for registration. Freshmen are expected to complete their registration on *Wednesday, September 16;* all others on *Thursday, September 17.* All men registering here for the first time will report for physical examination to Dr. R. B. Lawson in the gymnasium; all women will consult Mrs. M. H. Stacy, Adviser to Women, in her office in the South Building, third floor. Bills for tuition and fees are payable at the time of registration. For the winter and spring quarters the same hours will be used for freshmen and sophomores on days fixed by the calendar for the registration of students. All other students must register during the examination periods in December and March according to a schedule published immediately before these examinations begin. Registration in case of such students is not considered completed until they have settled their bills at the business office on the date of registration for freshmen and sophomores, and until they have attended all classes on the first day of the new quarter.

Registration for credit is limited to the first ten calendar days of a quarter.

Delayed Registration

The penalty for delayed registration for the winter and spring quarters is one month of strict probation for each day of delay. No excuses will be accepted.

Each student registering later than the day appointed for his registration for the winter or the spring quarter must pay five dollars ($5.00) as an additional fee for delayed registration.

Assignment of Rooms

The rooms in the University dormitories are assigned to students by the Cashier in the order of application, subject to the special regulations given below.

The University reserves the right to require any student whom for any reason it considers an undesirable tenant to vacate a room in the University buildings.

In order to retain his room for the next session, a student must file with the Cashier before May 25, an application and a deposit of $5.00 as an option. By December 10 another deposit of $5.00 must be made in order to retain the room for the winter and spring quarters. Double rooms must be applied for by both intending occupants. The rooms thus applied for will be retained until September 1 and January 1, respectively, when balance of rent is due. The $5.00 option deposit will be forfeited in case the applicant or applicants do not themselves occupy the room and pay the full rent. Rooms not applied for or made vacant by failure to pay at the proper date will be assigned in the order of application.

The right to occupy a room is not transferable and terminates with the expiration of the lease. Any attempt on the part of an occupant of a room to sell or transfer his right to occupancy shall be deemed a fraudulent transaction. The penalty for violating this rule shall be the forfeiture of the room by the new lessee.

The occupant of a room will be held directly responsible for any damage done to the furniture in his room or to the room.

No dogs shall be kept in the University dormitories. Breach of this regulation leads to forfeiture of the room.

Conduct

By order of the Board of Trustees the faculty is directed to dismiss from the University any student who is known to engage in drinking intoxicating liquors, gambling, hazing in any form (presence at hazing is regarded as participation), or to be guilty of dissolute conduct.

Students persistently neglectful of duty or addicted to boisterous conduct or rowdyism may be required to leave the University.

Students, unless *bona fide* residents of Chapel Hill, when suspended from the University for disciplinary reasons, must leave the campus

and Chapel Hill within forty-eight (48) hours or forfeit the right to readmission at any time. The enforcement of this regulation is in the hands of the Executive Committee of the Faculty.

Attendance

ARTICLE I

Sec. 1. Regular class attendance is a student obligation.

Sec. 2. The unexcused absence is not recognized as a student privilege.

Sec. 3. Any student having attained the honor roll during two consecutive quarters shall be exempt during the ensuing quarter from the regulations governing absences and shall be exempt thereafter so long as that student maintains the honor roll average. To the foregoing regulation there are to be the following exceptions: (a) the privilege of absence does not apply to attendance requirements relative to written or laboratory work or to quizzes and examinations; (b) the privilege earned by the student shall be forfeited if that student is absent without excuse immediately before or immediately after holidays.

Sec. 4. Departments or instructors may, on occasion, permit the student to attend or engage in an educational activity other than that of the class as a substitute for class attendance.

ARTICLE II

Sec. 1. The keeping of daily class attendance records is an obligation of the instructor.

Sec. 2. Collection of daily absence reports is an administrative responsibility. These reports shall be conveyed daily to the Registrar's office, where they shall be recorded promptly and be made available for use.

ARTICLE III

Sec. 1. Absences from class attendance for cause may be excused. Such absences are those due (a)* to participation in recognized University activities, as those of the Glee Club, debating and athletic teams, and the Playmakers, when occurring away from Chapel Hill, such excuses to be issued by the Registrar; (b)† those due to actual illness, testified to by the physician who attended the student in person during illness; and (c) those due to emergencies caused by extraordinary circumstances, when excused by the dean of the school concerned.

Sec. 2. The Registrar's office shall furnish to the student a record of excused absences for the information of instructors.

Sec. 3. The maximum number of unexcused absences shall not exceed, during any quarter, the number of weekly meetings of the

* Such authorized leaves of absence must be secured in advance.

† Excuses for illness must be reported within forty-eight hours from the time of the beginning of the illness.

class, provided that any department may impose penalties for a smaller number of absences.

Sec. 4. Absences immediately before or immediately after University holidays shall count as the maximum number described in Section 3 of this article.

Sec. 5. Any student who has incurred the maximum number of unexcused absences shall be placed on attendance probation, and in case of an additional unexcused absence may be suspended from the University by his dean. Before the decision is reached regarding suspension, the dean shall confer with the instructor or the head of the department involved or both.

ARTICLE IV

Sec. 1. Any student who is absent from a quiz or an examination at the appointed time thereof without excuse as defined above in Article III, Section 1, will not be permitted to make up this quiz or examination. Any department may impose a fee not exceeding one dollar ($1.00) upon the student having excuse for such absence for the privilege of taking a special quiz or examination or a make-up laboratory exercise.

ARTICLE V

Sec. 1. No student, unless exempted by Section 3 of Article I, shall be given credit in the University for any course unless that student has attended at least 75 per cent of the class meetings of the course during the quarter in which it is offered.

Sec. 2. Departments may require students who have been absent, whether the absences are excused or not, to make up work covered during the periods thereof.

Other Regulations Governing Attendance

In any quarter, absences are counted from the first regular meeting of each class. In no case will a student be considered present at any class until he has been registered as a member of that class.

A student who has been dropped for absences from a sufficient number of classes to reduce his schedule to one course will be suspended from the University for the remainder of the quarter on the ground of neglect of duty.

The grade of a student who quits a course without the permission of the dean of his college or school is recorded officially as F.

The grade of a student who drops a course in which he is failing at that time shall be recorded as F, unless, in the judgment of his dean, the reason for his failure be circumstances clearly beyond his control.

A student who is absent from any class without permission on the day immediately preceding or immediately following a holiday or recess shall go on strict probation for thirty days. Any student

may appeal his case in writing within five days to the Executive Committee of the Faculty.

Attendance at chapel is required of freshmen every week-day except Saturday and of sophomores on Mondays and Fridays. Absence from chapel will subject the student to discipline by the Executive Committee.

No student is allowed to absent himself from the University without written permission from the Registrar or his representative. This permission may, at the discretion of the executive officer, be granted only upon the formal request of the parent or guardian.

Examinations

Regular written examinations are required at the end of each quarter in all courses except those the nature of which is such as to make written examinations unnecessary.

Special examinations may be taken by students who have received the condition grade (E) at the period of the next special examinations in the week preceding the opening of the session in September.

Provided he has no conflict with a course regularly taken by him in the quarter, such a student may take an examination at any regular quarter examination in the same subject *within a year* after he has made the grade E. The grade E becomes F if the student fails to pass the special examination, or fails to remove the condition within a year.

Under no circumstances may a student stand a special examination to remove a condition grade (E) between the first and the last class days in any quarter.

Special examinations for students who have been officially excused from regular examinations on account of sickness or have been absent on account of some necessary cause may be held at suitable times fixed by the Registrar and the instructors concerned. Such examinations must be taken within twelve (12) months of the date of absence.

To be entitled to take a special examination within a quarter, or at the September period, or at a regular quarter examination period, the student is required to file with the Registrar at least one week prior to the examination period a written notice that he desires to take such examination.

Final examinations, except in laboratory practice, may not be held at any times other than those specified in the preceding regulations.

No examinations may be held later than 6:30 p.m.

All examinations must be held in Chapel Hill.

Examinations should be limited to a period of two hours. In courses in which a considerable portion of the examination is of a *practical* nature, the instructor may extend the time in his discretion.

No students other than the following should be permitted to take the examination in any course: 1st—regularly enrolled members of the class whose names have been reported from the Registrar's

office to the instructor as having registered in due form for the course; and 2nd—those whose names have been reported from the Registrar's office as having the right to take special examinations on that course.

Students absent from an examination without an official excuse or present and failing to submit examination papers are reported "absent." This mark is equivalent in every respect to grade F or failure, and is so reckoned in the office of the Registrar.

Each student is required to subscribe his name to the following pledge or its equivalent on every paper: "I hereby certify that during this examination I have neither given nor received aid." The instructor should not report a grade for any student whose examination paper lacks this pledge.

Papers handed in at a special examination by students who have been officially excused from the regular examination will be graded. All others will be marked "passed" or "failed."

Examinations for the removal of conditions of students in engineering will be given at 10:00 a.m. on Wednesday, September 9, 1931. By special permission of the Dean and Registrar, these examinations may be given at other times during the period September 9 to September 12, 1931.

Standing

After the close of each quarter reports of the standing of all students in all their studies are sent to parents or guardians. The reports are based upon the following system of marking:

Grade A, Excellent.
Grade B, Good.
Grade C, Fair.
Grade D, Barely passed.
Grade E, Conditioned.
Grade F, Failed.
*Grade I, Work incomplete.

A student must attain a grade of D to pass in any study. Grade E indicates that the student is conditioned but may remove the deficiency by special examination, as explained above. Students receiving grade F must repeat the study to receive any credit for the same.

A student has the right to appeal as to grading of his examination paper by his instructor. The appeal must be made to the President within three months after the examination. The President will appoint a committee of three persons who shall consider the case and whose decision shall be final.

* The grade I may be converted into one of the other grades by completing within a period of twelve months such additional assignments as may be required by the instructor in the course. A grade of I not so converted becomes F.

A student to be ranked as a sophomore must have passed seven courses; to be ranked as a junior, fifteen courses; to be ranked as a senior, twenty-six courses.

Undergraduate students, in order to be eligible to continue in the University, must qualify according to the following requirements: a freshman must pass at least two courses in the first two quarters, and at least five courses in the first three quarters. After the freshman year a student must pass at least one course each quarter, four courses in two successive quarters,* and seven courses in three successive quarters.* Deficiencies may be made up by correspondence work or in summer school, in which case only credits exceeding one course credit so obtained shall count for readmission. In three quarters, therefore, a freshman must pass at least five courses, or six if he is making up a shortage by correspondence work or in summer school; and one above freshman year similarly must pass at least seven courses, or eight if he is making good a deficiency by correspondence work or in summer school.

No student who fails to qualify under the above regulations may be readmitted to *any division* of the University except by a special vote of the faculty or a delegated committee of the faculty. This delegated committee of the faculty will meet at 9:00 a.m. on the *last* Saturday in July, at 9:00 a.m. on the second day *before* the stated registration day of each quarter, and at 9:00 a.m. on the second day *after* the stated registration day of each quarter to consider written petitions of students who have definite and convincing reasons on which to base a request that the rule be waived. All petitions should be sent to the Dean of the College of Liberal Arts *in writing* and, to be considered, must be in his hands *before* the stated meetings in that quarter in which the student seeks readmission.

Withdrawals

Formal withdrawal, which is a prerequisite to honorable dismissal or reëntrance to this institution, must be approved by the student's dean to be valid. Such a withdrawal will be approved only after full investigation of the circumstances and after the lapse of twenty-four hours from the time the first application is filed with the dean.

If a student withdraws after the mid-term and has been reported as below passing (either W or X) in two or more courses, that quarter will be counted as a quarter in residence in all computations of his requirements for readmission. If a student withdraws before mid-term, it will be left to the discretion of the dean as to whether or not that quarter is to be counted as a quarter in residence. The dean's verdict will be indicated specifically on the form used for withdrawal.

* By "two successive quarters" the last two quarters of residence are meant and by "three successive quarters" the last three quarters of residence are meant.

DEGREES IN ENGINEERING

Bachelor of Science

The degree of Bachelor of Science in Chemical, Civil, Electrical, or Mechanical Engineering will be conferred on students who have satisfactorily completed the four-year undergraduate program as listed under the department heading.

Master of Science

Those students who have satisfactorily completed a four-year undergraduate program and who are desirous of specializing further in some particular branch of engineering may spend an additional year at the University, and, after completing satisfactorily a prescribed course of study, may be awarded the degree of Master of Science. Graduates in engineering from institutions having undergraduate courses substantially equivalent to those given at the University of North Carolina may be admitted to graduate study either as special students or as candidates for the master's degree. The curriculum is essentially elective, courses to be chosen by the student to meet his individual preferences for a field of concentration. Nine full courses of advanced character are ordinarily required for the degree; six of these will usually lie in the candidate's major field of study, the other three being elected in subjects allied to that field. The courses required for a graduate degree in the several special branches of engineering are stated on pages 35-40, and detailed descriptions are to be found on pages 41-56.

Distinct opportunities for research and graduate study are offered in all departments of the school. Through close coöperation with the State Highway Commission, the State Board of Health, and other agencies, many interesting problems are presented in the field of research which qualified students may undertake, and the laboratories are designed with the idea in mind of offering the student opportunities for carrying on such research work.

At present two research fellowships are available for graduate students. These fellowships are open to students who have received a bachelor's degree in engineering and have attained a high scholarship record in their undergraduate work.

Research

Engineering research projects of considerable importance are being carried on by the School of Engineering. During the past eight years this division of the University has coöperated with various federal and state agencies, municipalities, corporations, and engineering and research organizations in studies and investigations that

have resulted in the development of data and information of great value to the engineering profession. For five years the Department of Civil Engineering has conducted an extensive series of experiments to determine friction and cohesion factors on earth and the pressures on culvert pipe of various types and sizes under different conditions of fill. Investigations of rainfall, stream flow, silting, evaporation, and beach erosion have been made in coöperation with the State Department of Conservation and Development. Studies on filter sands, water, sewage and industrial waste treatment, chlorination, mosquito and malaria control, stream sanitation, and allied public health problems have been carried out coöperatively with the State Board of Health. Extensive research has been conducted on columns, rigid frames, and welded joints. In Electrical Engineering, studies are being made on vacuum-tube amplifying circuits for thermocouples. In Mechanical Engineering research is in progress on the cyclic heat flow in spherical bodies and the response of thermocouples to rapidly oscillating temperatures. The Department of Chemical Engineering is engaged in investigations of the elimination of sulphur from North Carolina coals, the recovery of alkalis from North Carolina feldspars, and research relating to crystallization and filtration.

Programs of Undergraduate Study

S.B. in Chemical Engineering

FRESHMAN YEAR

Mathematics 1E, 2E, 3E; Chemistry 1, 2, 42; English 9abc; General Engineering 1abc, 6abc.

SOPHOMORE YEAR

Mathematics 24E, 25E, 26E; Chemistry 41; Physics 21E, 22E, 23E; English 29ab; General Engineering 26abc, 36abc; Chemical Engineering 91; Electrical Engineering 32ab.

FIRST JUNIOR SUMMER SESSION

History 85; Chemistry 61, 62; Electrical Engineering 52a; Mechanical Engineering 53a.

JUNIOR YEAR

Economics 31, 32; English 59; German 1, 2; Chemistry 81, 82, 91; General Engineering 56a; Chemical Engineering 94; Electrical Engineering 52bc; Mechanical Engineering 53bc.

SENIOR YEAR

English 60abc; Commerce 51E, 52E, 53E; Chemistry 43, 191, 192; Chemical Engineering 191, 194, 195, 196, 197. Electives, 10 quarter-hours, from the following courses:

General Engineering 116a; Civil Engineering 65a; Mechanical Engineering 48abc; Geology 11, 12, 43-44; Chemistry 66, 92, 93, 163, 164, 165, 183, 184, 185.

S.B. in Civil Engineering

FRESHMAN YEAR

Mathematics 1E, 2E, 3E; Chemistry 1, 2, 42; English 9abc; General Engineering 1abc, 6abc.

SOPHOMORE YEAR

Economics 31; Mathematics 24E, 25E, 26E; Physics 21E, 22E, 23E; English 29ab; General Engineering 26abc, 36abc; Civil Engineering 20abc, 25a; Electrical Engineering 32ab.

FIRST JUNIOR SUMMER SESSION

Economics 32; Civil Engineering 55a, 60a; Electrical Engineering 52a; Mechanical Engineering 53a.

COÖPERATIVE JUNIOR YEAR

(Including Second Junior Summer Session)

English 59; History 85; General Engineering 56a; Civil Engineering 65a, 70a; Electrical Engineering 52bc; Mechanical Engineering 53bc.

SENIOR YEAR

English 60abc; Commerce 51E, 52E, 53E; Geology 77, 78; Civil Engineering 160abc, 165abc, 170abc, 175abc.

S.B. in Electrical Engineering

FRESHMAN YEAR

Mathematics 1E, 2E, 3E; Chemistry 1, 2, 42; English 9abc; General Engineering 1abc, 6abc; Electrical Engineering 2abc.

SOPHOMORE YEAR

Economics 31; Mathematics 24E, 25E, 26E; Physics 21E, 22E; English 29ab; General Engineering 26abc; Civil Engineering 30a; Electrical Engineering 22abc; Mechanical Engineering 48abc.

FIRST JUNIOR SUMMER SESSION

Economics 32; Electrical Engineering 62a; Mechanical Engineering 63a, 68a.

COÖPERATIVE JUNIOR YEAR

(Including Second Junior Summer Session)

History 85; English 59; General Engineering 56a; Civil Engineering 65a; Electrical Engineering 57a, 62bc; Mechanical Engineering 63bc, 68a.

SENIOR YEAR

English 60abc; Commerce 51E, 52E, 53E; Electrical Engineering 67a, 77a, 87a, 97abc, 102a, 112a, 122a, 162abc, 172abc.

S.B. in Mechanical Engineering

FRESHMAN YEAR

Mathematics 1E, 2E, 3E; Chemistry 1, 2, 42; English 9abc; General Engineering 1abc, 6abc.

SOPHOMORE YEAR

Economics 31; Mathematics 24E, 25E, 26E; Physics 21E, 22E, 23E; English 29ab; General Engineering 26abc, 36abc; Civil Engineering 30a; Electrical Engineering 32ab; Mechanical Engineering 48abc.

FIRST JUNIOR SUMMER SESSION

Economics 32; Electrical Engineering 52a; Mechanical Engineering 63a, 68a.

COÖPERATIVE JUNIOR YEAR
(Including Second Junior Summer Session)

History 85; English 59; General Engineering 56a; Civil Engineering 65a; Electrical Engineering 52bc; Mechanical Engineering 63bc, 66a.

SENIOR YEAR

Commerce 51E, 52E, 53E; English 60abc; Mechanical Engineering 78abc, 88abc; Heat-power Option: Mechanical Engineering 73a, 83a, 93a; Aeronautical Option: Mechanical Engineering 166a, 176ab, 186ab.

SUGGESTIONS TO STUDENTS ENTERING WITH ADVANCED STANDING

For students who, after taking a degree or a pre-engineering course at an accredited liberal arts college, contemplate completing the engineering course in three years, the following subjects are recommended as a part of their liberal arts curriculum:

Mathematics—Algebra, solid geometry, trigonometry, analytical geometry, differential and integral calculus, and differential equations.
English—A two-year course including composition, public speaking, and English literature.
Chemistry—General descriptive chemistry, qualitative and quantitative analysis.
Physics—General physics, based upon a knowledge of trigonometry.
History—Foundations of modern civilization.
Economics—General economics.

As a guide for the general content of the courses suggested above, the student should consult the descriptions of the required courses given later in this catalogue. Equivalent courses should be given by any accredited liberal arts college.

PROGRAMS OF GRADUATE STUDY

Courses Leading to the Degree of Master of Science

PREREQUISITES

The subjects of major study may be chemical engineering, civil engineering, electrical engineering, or mechanical engineering, and the prerequisite courses are the courses leading to the following degrees: S.B. in Chemical Engineering, S.B. in Civil Engineering, S.B. in Electrical Engineering, and S. B. in Mechanical Engineering. Before becoming a candidate for the advanced degree the student

must complete the courses leading to the corresponding bachelor's degree as outlined in this catalogue, or equivalent.

I. MASTER OF SCIENCE IN CHEMICAL ENGINEERING

The profession of chemical engineering is becoming of greater and greater importance. With the recent phenomenal growth of industry has come a realization on the part of employers that there is a definite need for men whose training combines chemistry with applied mathematics and physics. The problems involved in the expansion of modern manufacturing, and in the development and production of new materials must be solved in a large measure by the chemical engineer. Industry has been quick to recognize the desirability of graduate study for chemical engineers, and a definite demand exists for men with advanced degrees. To meet this need, a curriculum leading to the degree of Master of Science in Chemical Engineering has been developed.

Majors, required:
Seminar in chemical engineering, Ch. E. 291-2-3.
Research in chemical engineering, Ch.E. 391-2-3.
Chemistry, one and one-half approved courses.

Minors, three courses in one or two of the following departments:

General Engineering	Mathematics
Civil Engineering	Physics
Electrical Engineering	Economics and Commerce
Mechanical Engineering	Geology

II. MASTER OF SCIENCE IN CIVIL ENGINEERING

A. *Municipal and Sanitary Engineering*

With the rapid increase in the growth of cities in North Carolina and other southern states, there has come about a wide demand for engineers trained to plan and administer the various technical activities of the modern city; therefore, a fifth-year program has been especially designed as a preparation for the important duties of city manager and city engineer. The four undergraduate years are identical with those in the curriculum leading to the degree of S.B. in Civil Engineering. A thorough treatment is given to the fundamental principles underlying the design and operation of streets, city planning, water works, and sewerage systems, water and sewage treatment plants, garbage and refuse disposal, and drainage. Approved courses in commerce present the basic facts in business administration which are required of all engineering administrators.

Majors, six approved courses from the following:
Regional and city planning, C. E. 260ab.
Advanced sanitary engineering, C. E. 265abc.
Hydrology, C. E. 280a.
Sanitary chemistry and biology, C. E. 290abc.
Research in hydraulic and sanitary engineering, C. E. 365abc.

Minors, three approved courses from one or two of the following departments:

General Engineering
Electrical Engineering
Mechanical Engineering
Bacteriology
Zoölogy
Chemistry
Geology
Economics and Commerce
History and Government
Psychology
Sociology

B. *Highway Engineering*

North Carolina has assumed a position of leadership in road building among the states in the Union, and consequently there is a demand for engineers who are trained as specialists in highway construction. Opportunities for employment are open to men who have specialized in highway work with the Federal Government, State Highway Commission, county highway commissions, various municipalities, and with contractors handling highway work. The closest coöperation exists between the State Highway Commission and the University, and students are brought into contact with the state highway organization. The four undergraduate years are identical with those in the course leading to the degree of S.B. in Civil Engineering. In his undergraduate courses the student is given thorough fundamental training in highway and railway engineering, and the design of steel and reinforced concrete structures. Using these courses as a foundation, the student is required in his fifth year to specialize and to acquire a detailed knowledge of the problems of highway construction.

Majors, six approved courses from the following:

Advanced concrete structures, C. E. 275abc.
Regional and city planning, C. E. 260abc.
Highway engineering research and design, C. E. 360abc.
Advanced engineering materials, G. E. 236abc.

Minors, three approved courses from one or two of the following departments:

General Engineering
Chemical Engineering
Mechanical Engineering
Chemistry
Geology
Economics and Commerce
Sociology
History and Government
Rural Social-Economics

C. *Structural Engineering*

Structural engineering includes the design and construction of all kinds of buildings and bridges and similar structures; for example, typical structures such as the Empire State Building, the Hell Gate and Hudson River bridges, or the immense Panama Canal lock gates. The structural engineer is called upon as a specialist in almost all branches of engineering, because structures of timber, concrete, or steel are found in the construction of nearly every engineering undertaking. The four undergraduate years are identical with those of the course of study leading to the degree of S.B. in Civil Engineering. In the fifth year the student devotes himself to

specialized and intensive courses and research in structural engineering.

Majors, six approved courses from the following:
Advanced steel structures, C. E. 270abc.
Advanced reinforced concrete structures, C. E. 275abc.
Research in structural engineering, C. E. 370abc.
Advanced engineering materials, G. E. 236abc.
Advanced strength of materials, G. E. 256abc.

Minors, three approved courses from one or two of the following departments:
General Engineering
Chemical Engineering
Electrical Engineering
Mechanical Engineering
Chemistry
Economics and Commerce
Geology
Mathematics
Physics

D. *Hydro-Electric Engineering*

Problems incident to the rapid increase in the development of the great water powers of the South and nation, with the accompanying complexities of generation, transmission, and distribution of electric energy, have created a wide demand for engineers especially trained in the field of hydro-electric engineering. This course is particularly designed to meet the needs of students intending to enter the service of the various power and public utility companies or public service commissions, and for engineers now in practice who desire to return for a year of specialized work or research in some of the problems confronting the hydro-electric industry. The four undergraduate years are identical with those in either civil, electrical, or mechanical engineering. In the fifth or graduate year, the student will pursue specialized course and research work, and will visit and report on several of the leading hydro-electric and steam-power plants of the state.

Majors, six approved courses from the following:
Hydrology, C. E. 280a.
Water-power engineering, C. E. 285abc.
Advanced reinforced concrete structures, C. E. 275abc.
Research in hydraulic engineering, C. E. 365abc.
Electric transients, E. E. 262a.
Hyperbolic functions applied to transmission problems, E. E. 272a.
Design of transmission systems, E. E. 282a.
Electrical engineering research and design, E. E. 382abc.

Minors, three approved courses from one or two of the following departments:
General Engineering
Chemical Engineering
Electrical Engineering
Mechanical Engineering
Chemistry
Geology
Economics and Commerce
History and Government

III. MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

With the splendid facilities of the electrical engineering laboratories in Phillips Hall, the school is able to offer excellent advantages for

advanced work in laboratory investigation and engineering design. The laboratories comprise a total of nearly seven thousand square feet of floor space divided into a large dynamo laboratory containing over fifty generators, motors, and transformers; a standardization laboratory equipped with a wide range of precision standards for both direct and alternating current measurements; a well-equipped photometric laboratory; a radio laboratory, and a special research laboratory equipped with a complete General Electric oscillograph outfit. All of these laboratories are supplied with direct and alternating current power by means of a plug and socket system of connections. The University Power Plant offers excellent additional facilities for commercial testing and economic study of an advanced nature. The four undergraduate years are identical with those of the course leading to the degree of S.B. in Electrical Engineering. The fifth or graduate year is devoted to specialized work in courses, research, and design.

Majors, six approved courses from the following:

Electric transients, E. E. 262a.
Hyperbolic functions applied to transmission problems, E. E. 272a.
Design of transmission systems, E. E. 282a.
Electrical engineering research and design, E. E. 382abc.

Minors, three approved courses from one or two of the following departments:

General Engineering
Chemical Engineering
Civil Engineering
Mechanical Engineering
Chemistry
Economics and Commerce
Mathematics
Physics

IV. MASTER OF SCIENCE IN MECHANICAL ENGINEERING

In the regular four-year course in mechanical engineering of this University the training given is designed for the broader professional field, that is, for the designing and directing positions in industry. In this training two distinct, though related, fields are emphasized—machine design and heat-power engineering. Opportunity for advanced study in both of these fields is offered to qualified graduates. In the senior year of the four-year course the student may elect the aeronautical or the power option. It is possible by a fifth year of graduate work to complete the senior option not elected, in addition to pursuing other advanced courses. For the study of heat-power problems, the steam and gas laboratory is well equipped with modern heat engines, and the fuel and oil testing laboratory has excellent facilities for the study of fuels and lubricating oils.

Majors, six approved courses from the following:

Advanced engineering thermodynamics, M. E. 283abc.
Advanced mechanical design, M. E. 288abc.
Aerodynamics, M. E. 166a.
Airplane design, M. E. 176ab.
Airplane Engines, M. E. 186ab.
Advanced strength of materials, G. E. 256abc.

Minors, three approved courses from one or two of the following departments:

General Engineering	Chemistry
Chemical Engineering	Mathematics
Civil Engineering	Physics
Electrical Engineering	Economics and Commerce

OTHER REQUIREMENTS

The requirements regarding modern language, thesis, examination, committee, residence, and conferring of degrees are the same as for the degree of Master of Arts, with the following exceptions: (a) candidates for the degree of M.S. in the departments of Civil, Electrical, or Mechanical Engineering are not required to have a reading knowledge of a modern foreign language. (b) Candidates for the degree of M.S. in the Department of Chemical Engineering are required to have a reading knowledge of either French or German technical literature. (See catalogue of Graduate School for general requirements and regulations applying to graduate students.)

COURSES OF INSTRUCTION

Except by special permission and as noted below (Courses Civil Engineering 35a and 40a), courses in engineering are open to students in engineering only.

The courses offered in the School of Engineering are described below under the general headings under which they naturally fall—General Engineering, Chemical Engineering, Civil Engineering, Electrical Engineering, and Mechanical Engineering.

GENERAL ENGINEERING

Courses for Undergraduates

G.E. 1abc. MECHANICAL DRAWING AND DESCRIPTIVE GEOMETRY.

Lettering and use of drawing instruments. Descriptive geometry, covering fundamental problems of the point, line, and plane and their application to problems of the intersection and development of surfaces. Problems in orthographic and isometric projections. *Two lecture and four laboratory hours a week, fall, winter, and spring quarters.* Value 12 quarter-hours. Professors Smith, Michel, Messrs. Watson, Slade.

G.E. 6abc (3abc). ELEMENTARY MECHANICS. Corequisites, Mathematics 1-2-3E.

The basic principles of statics and an elementary course in strength of materials, covering conditions of equilibrium, force, and funicular polygons, center of gravity, friction, beams, and jointed structures. This course correlates with first year mathematics and drawing. *Two lecture hours a week, fall, winter, and spring quarters.* Value 6 quarter-hours. Professors Saville, Baity, Smith, Messrs. Hollett, Watson, Slade.

G.E. 26abc (4abc). MECHANICS. Prerequisites, Mathematics 1-2-3E, General Engineering 6abc.

The fundamental conceptions of statics including resultants of force systems, equilibrium of force systems, friction, centroids, moments of inertia of areas and bodies. This course correlates with sophomore mathematics. *Three lecture hours a week, fall, winter, and spring quarters.* Value, 9 quarter-hours. Professor Trimble, Mr. Slade.

G.E. 36abc (6bc). MATERIALS OF ENGINEERING.

Constitution, physical properties, and tests of the important materials, such as wood, cement, stone, iron, steel, etc., used in engineering construction; metallurgy or iron and steel and the more important alloys. Civil and chemical engineering students required to take all lecture and laboratory work. Mechanical engineering students required to take lectures only. *Two lecture hours a week, fall quarter, two lecture and three laboratory hours a week, winter and spring quarters. Laboratory fee, $4.00 a quarter for winter and spring.* Value, 9 quarter-hours for civil and chemical, and 6 quarter-hours for mechanical engineering students. Professors Trimble, White, Mr. Hollett.

G.E. 56a (5abc). APPLIED MECHANICS AND STRENGTH OF MATERIALS. Prerequisites, Mathematics 24E-25E-26E, General Engineering 26abc.

Kinematics and kinetics of particles and rigid bodies, including translation, rotation, and plane motion; the principles of work and energy, impulse and momentum. The fundamental principles governing the strength and behavior of beams, columns, truss members, shafting, and various kinds of connections.

Parallel laboratory exercises comprise tests of brittle and ductile materials in direct stress, and of riveted and welded joints. Experimental determination of stresses and deflections in beams and columns and the comparison of these results with calculated values. *Five lecture and three laboratory hours a week, fall or summer quarters. Laboratory fee, $5.00.* Chemical engineering students do not take laboratory work or pay laboratory fee. Value for chemical engineering students 5 quarter-hours; for civil, electrical, and mechanical engineering students, 6½ quarter-hours. Professors Hickerson, Trimble, Bailey.

Course for Graduates and Advanced Undergraduates

G.E. 116a (100c). CONTRACTS AND SPECIFICATIONS.

A course covering the laws of contracts, a detailed study of methods of writing correct specifications, the matter of securing or submitting bids, and the subject of bid bonds. *Three lecture hours a week, spring quarter.* Value, 3 quarter-hours. Professor Saville.

Courses Primarily for Graduates

G.E. 236abc (106abc). ADVANCED ENGINEERING MATERIALS. Prerequisite, General Engineering 36abc, or the equivalent.

Composition and physical properties of materials used in engineering construction; specifications and inspection methods; investigation of special properties and uses of important materials; improved methods of testing and manufacture; development of new methods of specification. *Three lecture and six laboratory hours a week, fall, winter, and spring quarters. Laboratory fee, $5.00 a quarter.* Value, 6 quarter-hours a quarter. Professor Trimble.

G.E. 256abc (105abc). ADVANCED STRENGTH OF MATERIALS. Prerequisite, General Engineering 56a.

General theory of flexure, combined stresses, Lamé's theory for thick hollow cylinders, flexure of curved beams; and other theoretical and empirical matter on the general subject of strength of materials that is not treated exhaustively in the undergraduate curriculum of most engineering schools. *Three lecture hours a week, fall, winter, and spring quarters.* Value, 9 quarter-hours. Professor Hickerson, Mr. Noe.

CHEMICAL ENGINEERING

Courses for Undergraduates

Ch.E. 91 (2). INTRODUCTORY CHEMICAL ENGINEERING.

A survey course covering materials used in the construction of chemical equipment, search of literature, elementary calculations, etc. In the laboratory the students assist the seniors in carrying out studies of the unit operations. *Three lecture and six laboratory hours a week, spring quarter.* Value, 6 quarter-hours. Professor White.

Ch.E. 94 (1). METALLURGY AND METALLOGRAPHY. Corequisite, Ch.E. 91.

A study of the microscopic structure of ferrous and non-ferrous alloys and the effects of composition, heat treatment, and mechanical work upon these structures and the physical properties of these ferrous alloys. A portion of the course is devoted to laboratory study. *Three lecture and six laboratory hours a week, spring quarter. Laboratory fee, $7.00.* Value 6 quarter-hours. Professor White.

Courses for Graduates and Advanced Undergraduates

Ch.E. 191 (6). CHEMICAL ENGINEERING LABORATORY. Prerequisites, Ch.E. 194, 195; corequisite, Ch.E. 196.

Efficiency studies on chemical equipment, plant erection studies, and unit process work in the laboratory. *Two lecture and six laboratory hours a week, spring quarter. Laboratory fee, $10.00.* Value, 5 quarter-hours. Professor White.

Ch.E. 194-195-196 (3abc). PRINCIPLES OF CHEMICAL ENGINEERING. Prerequisites, Ch.E. 91, 94.

A study of the unit operations of chemical engineering, covering fluid flow, filtration, evaporation, distillation, etc. *Three hours a week, fall, winter, and spring quarters.* Value, 9 quarter-hours. Professor White.

Ch.E. 197 (7). CHEMICAL ENGINEERING CALCULATIONS.

A study of material and heat balances in industrial processes. *Five hours a week, fall quarter.* Value, 5 quarter-hours. Professor White.

Courses Primarily for Graduates

Ch.E. 291-292-293. SEMINAR IN CHEMICAL ENGINEERING.

A discussion and library course. Selected advanced topics in the field of chemical engineering will be studied. For the year 1931-32 the subject of the work will be combustion. *Two class and two library hours a week, fall, winter, and spring quarters.* Value, 9 quarter-hours. Professor White.

Ch.E. 391-392-393. RESEARCH IN CHEMICAL ENGINEERING.

Research towards an advanced degree, the subject of which must be approved by the professor in charge. *One lecture and nine laboratory hours a week, fall, winter, and spring quarters.* Value, 16½ quarter-hours. Professor White.

CIVIL ENGINEERING

Courses for Undergraduates

C.E. 20abc (2c). CIVIL ENGINEERING DRAWING. Prerequisite, General Engineering 1abc. For civil engineering students.

Lettering and titling, map and blue print reading, topographic and traverse plotting, computing and estimating. *One lecture and three laboratory hours a week, fall, winter, and spring quarters.* Value 7½ quarter-hours. Professor Smith, Mr. Hollett.

C.E. 25a (22a). FIELD EXERCISES IN SURVEYING.

Prerequisites, Mathematics 1-2-3E. For civil engineering students.

Practice in the use and adjustments of tape, level, transit, plane table, etc., supplemented by the solution of field problems. *Three laboratory hours a week, fall quarter. Laboratory fee, $4.00.* Value, 1½ quarter-hours. Mr. Hollett.

C.E. 30a (22c). ELEMENTARY PLANE SURVEYING. Prerequisites, Mathematics 1-2-3E.

An elementary course in the use and adjustments of surveying instruments for students in electrical and mechanical engineering. *One lecture and three laboratory hours a week, spring quarter. Laboratory fee, $4.00.* Value, 2½ quarter-hours. Professor Trimble, Mr. Hollett.

C.E. 35a (20c). SURVEYING AND PLOTTING FOR NON-ENGINEERING STUDENTS. Prerequisites, Mathematics 1, 2.

Methods of using the compass, transit, tape, and level in making ordinary surveys for land boundaries, acreage, volumes, profiles, and the establishment of lines in their true position. It involves field measurements of distances and

angles, the plotting and description of maps from such data, and the computation of areas, volumes, grade lines, true meridian, etc. *Three lecture and six laboratory hours a week, spring quarter. Laboratory fee, $6.00.* Value, 6 quarter-hours. Professor Trimble, Mr. Slade.

C.E. 40a (16c). PLANE TABLE SURVEYING AND MAPPING. Prerequisites, Mathematics 1-2-3E, or the equivalent. Open to non-engineering students.

Preparation and interpretation of topographical maps. Lectures and field work. *One lecture and three laboratory hours a week, spring quarter. Laboratory fee, $4.00.* Value 2½ quarter-hours. Professor Trimble, Mr. Hollett.

C.E. 55a. PLANE SURVEYING. Prerequisites, Mathematics 1-2-3E, Civil Engineering 25a.

Elements of plane surveying theory. Intensive practice in the use of instruments and the solution of field problems. For civil engineering students who expect to attend the summer engineering camp. *Five lecture and three laboratory hours a week, first term of summer quarter. Laboratory fee, $4.00.* Value 3¼ quarter-hours. Professor Trimble.

C.E. 60a (23s). SUMMER ENGINEERING CAMP. Prerequisites, Civil Engineering 25a, 55a, or equivalent.

Instruction in plane, topographic, railway, and highway surveying is given during the second six weeks of the summer term following the sophomore year. The course includes the following subjects: I. Chaining; differential, profile and cross-section leveling; plane-table, transit and stadia topographic surveys; solar and stellar observations for the determination of meridian and latitude; triangulation including base line measurement; measurement of stream discharge; hydrographic surveying. II. Simple, compound, reversed, spiral and vertical curves; frogs and turnouts; reconnaissance surveys; preliminary surveys; paper location; final location; mass diagrams and earthwork computation; slope-staking; estimate of quantities and costs. III. Topographical drawing, mapping of traverse and boundary surveys, area computation and other work of a similar nature. *Five lecture and forty laboratory hours a week, second summer term. Laboratory fee, $8.00.* Value 12½ quarter-hours. Professor Trimble.

C.E. 65a (32bc). HYDRAULICS. Prerequisites, Mathematics 24E-25E-26E.

The principles of flow of water through orifices, weirs, tubes, nozzles, pipes, and open channels as applied to measurement of water in hydraulic engineering practice. The fundamental principles of impulse wheels, reaction turbines, and centrifugal pumps. *Four lecture and three laboratory hours a week, winter or spring quarter. Laboratory fee, $4.00.* Value 5½ quarter-hours. Professor Saville, Mr. Watson.

C.E. 70a (12ab). GRAPHIC STATICS. Prerequisite, General Engineering 26abc.

Graphic determination of stresses in framed structures. *One lecture and three laboratory hours a week, fall or winter quarters.* Value 2½ quarter-hours. Professor Smith, Mr. Slade.

Courses for Graduates and Advanced Undergraduates

C.E. 160abc (44abc, 45abc). CITY PLANNING, HIGHWAY AND RAILWAY ENGINEERING. Prerequisite, Civil Engineering 60a, or equivalent experience.

The first quarter is devoted to a study of growth of cities, street plans, subdivisions, housing, recreational facilities, zoning, transportation terminals, traffic regulations. The second quarter is concerned with the study of location, con-

struction, and maintenance of the various types of highways, characteristics of road materials, highway administration, legislation, organization, and financing. In the third quarter are considered the problems and economics of railroad location and road bed construction and such practical subjects as ballast, ties and tie-plates, rails, frogs and switches, fences and cattleguards, bridge and trestle floors, track signs, etc.

Parallel laboratory exercises consist of practical and specific problems in city planning, location of highways and railways, the physical and chemical testing of road materials, study of reports, and observation of projects under construction and completed. *Three lecture and three laboratory hours a week, fall, winter, and spring quarters. Laboratory fee, $4.00 a quarter.* Value, 13½ quarter-hours. Professor Trimble.

C.E. 165abc (34abc, 35abc). HYDRAULIC AND SANITARY ENGINEERING. Prerequisite, Civil Engineering 65a.

The epidemiological background, principles and practice of sanitation and public health engineering; the theory and fundamentals of design, construction, and operation of water supply and sewerage systems, water purification and sewage treatment plants, as applied to municipalities and rural communities. Attention is given to studies of rainfall, stream flow, and storage as applied to water supply, water power, and waste disposal. Parallel laboratory exercises comprise problems in the layout and design of simple water supply and sewerage systems and water and sewage treatment works. Training is given in the operation of such utilities and the routine laboratory technique employed in their control. *Three lecture and three laboratory hours a week, fall, winter, and spring quarters. Laboratory fee, $4.00 a quarter.* Value, 13½ quarter-hours. Professors Saville, Baity, Messrs. Hollett, Slade.

C.E. 170abc (14abc, 15abc). STEEL STRUCTURES. Prerequisites, General Engineering 56abc and Civil Engineering 70a.

Theory of determinate structures, graphical and analytical determination of direct and secondary stresses occurring in engineering structures, such as roofs, bridges, buildings, dams, retaining walls, etc. Parallel design exercises comprise specific and complete problems in steel and timber structures, such as buildings, industrial plants, roof and bridge trusses and girders, retaining walls, and water towers. *Two lecture and three laboratory hours a week, fall and winter quarters, two lecture and six laboratory hours a week, spring quarter.* Value 12 quarter-hours. Professors Hayes, Smith.

C.E. 175abc (24abc, 25abc). REINFORCED CONCRETE STRUCTURES. Prerequisite, General Engineering 56abc.

Development of the mathematical principles involved in the design of plain and reinforced concrete beams, slabs, columns, foundations, retaining walls, arches, and girders. Parallel laboratory exercises comprise specific and complete problems illustrating the use of these structural elements in the design of buildings, bridges, and other reinforced concrete structures. *Two lecture and three laboratory hours a week, fall, winter, and spring quarters.* Value, 10½ quarter-hours. Professor Hickerson, Mr. Noe.

Courses Primarily for Graduates

C.E. 260ab (135bc). REGIONAL AND CITY PLANNING. Prerequisites, Civil Engineering 160abc, 165abc, or equivalent.

Following an historical résumé of the subject, there is presented by means of lectures and readings a detailed topical analysis of the broad principles governing modern practice. The legal aspects are first treated, followed by consideration of the effects of physical factors, such as topography, river or sea front, etc. Consideration of communication facilities includes street plan, traffic control, transportation and transit problems, and port and industrial development. Zoning, housing, recreation, public health, statistics, public safety, and methods

of financing precede a final analysis of numerous city or regional plans in effect in different parts of the country. *Three hours a week, winter and spring quarters.* Value, 3 quarter-hours a quarter. Professors Saville, Trimble, and other members of the graduate faculty.

C.E. 265abc (130abc). ADVANCED SANITARY ENGINEERING. Prerequisites, Civil Engineering 65a, Civil Engineering 165abc, or their equivalent.

An advanced course in sanitary and public health engineering, including the design and operation of water supply and sewerage systems, water and sewage treatment plants, water rate studies, leakage surveys, financial management, stream sanitation, industrial waste disposal, rural sanitation, garbage disposal, drainage, malaria control, etc. Occasional lectures are given by practising engineers, public works and public health officials. *Three hours a week, fall, winter, and spring quarters.* Value, 9 quarter-hours. Professors Saville, Baity.

C.E. 270abc (114abc). ADVANCED STEEL STRUCTURES. Prerequisites, Civil Engineering 170abc and Civil Engineering 175abc.

Secondary stresses and statically indeterminate structures, including steel arches, cantilever, suspension and movable bridges. *Three hours a week, fall, winter, and spring quarters.* Value, 9 quarter-hours. Professor Hickerson, Mr. Noe.

C.E. 275abc (124abc). ADVANCED REINFORCED CONCRETE STRUCTURES. Prerequisites, Civil Engineering 170abc and Civil Engineering 175abc.

A study of the theory and design of multiple arch dams, domes, rigidly connected frames, unsymmetrical bridges, etc. *Three hours a week, fall, winter, and spring quarters.* Value, 9 quarter-hours. Professor Hickerson, Mr. Noe.

C.E. 280a (132a). HYDROLOGY. Prerequisite, Civil Engineering 165abc, or equivalent.

A detailed study of meteorology, rainfall, stream flow, storage, and other factors influencing hydrological investigations. The application of modern statistical methods to such problems is particularly stressed. *Three hours a week, fall quarter. Laboratory fee, $2.00.* Value, 3 quarter-hours. This course may be continued for additional credit. Professor Saville.

C.E. 285ab (134bc). WATER POWER ENGINEERING. Prerequisite, Civil Engineering 280a, or equivalent.

The investigation and design of water power developments, including preliminary hydrological studies, investigation of dam foundations, dam design, characteristics and selection of turbines, etc. A complete report will be prepared, including estimated cost of development, market for power, relation to other power systems, and financing. This course may be followed by Electrical Engineering 262a, 272a, 282a. *Three hours a week, winter and spring quarters. Laboratory fee, $2.00 a quarter.* Value, 6 quarter-hours. Professor Saville.

C.E. 290abc (133abc). SANITARY CHEMISTRY AND BIOLOGY FOR ENGINEERING STUDENTS. Prerequisites, Chemistry 1-2, Civil Engineering 165abc, or equivalent.

A course designed to give intensive training in the laboratory methods employed in sanitary engineering practice. The work includes microscopical examinations; physical, chemical, and bacteriological determinations on water, air, milk, sewage, and industrial wastes; the analysis of sand and gravel for filtration purposes; limnological studies of streams and reservoirs; stream pollution investigations; and the application of laboratory tests to the control of sanitary works. Class and laboratory exercises are supplemented by field work and plant inspections. *Four to twelve laboratory hours a week, fall, winter, and spring quarters. Laboratory fee, $5.00 a quarter.* Value, 6 to 18 quarter-hours. Professor Baity.

C.E. 360abc (145abc). HIGHWAY ENGINEERING RESEARCH AND DESIGN. Prerequisite, Civil Engineering 160abc, or equivalent.

Laboratory research problems in highway materials; investigation of problems in the scientific design and construction of modern road types; problems involving the development of equipment for use in investigation or specification of methods and materials. *Three lecture and six laboratory hours a week, fall, winter, and spring quarters. Laboratory fee, $5.00 a quarter.* Value, 6 quarter-hours a quarter. Professor Trimble.

C.E. 365abc (131abc). RESEARCH IN HYDRAULIC AND SANITARY ENGINEERING. Prerequisite, Civil Engineering 165abc, or equivalent.

For graduate or special students desiring to conduct investigations in hydrology, hydraulics, water or sewage treatment, or stream pollution. *Four to twelve laboratory hours a week, fall, winter, and spring quarters. Laboratory fee, $5.00 a quarter.* Value, 6 to 18 quarter-hours. Professors Saville, Baity.

C.E. 370abc (125abc). RESEARCH IN STRUCTURAL ENGINEERING. Prerequisites, Civil Engineering 170abc, 175abc, or equivalent.

A course for graduate students desiring to engage in an intensive analytical or experimental investigation of structural engineering problems. *Three lecture and six laboratory hours a week, fall, winter, and spring quarters. Laboratory fee, $5.00 a quarter.* Value, 6 quarter-hours a quarter. Professors Hickerson, Trimble.

ELECTRICAL ENGINEERING

Courses for Undergraduates

E.E. 2abc (61abc). INTRODUCTION TO ELECTRICAL ENGINEERING. The aim of this course is to give the student an acquaintance with the materials, apparatus, and terminology used in electrical engineering. The fundamental principles of current, voltage, resistance, energy, and power are studied by means of practical problems with commercial apparatus. Practical work in wiring, together with a study of the National Electric Code, is given in the spring quarter. *Two lecture and two laboratory hours a week, fall, winter, and spring quarters. Laboratory fee, $4.00 a quarter.* Value, 9 quarter-hours. Professor Lear, Mr. Stainback.

E.E. 22abc (62bcs). ELEMENTS OF ELECTRICAL ENGINEERING. Prerequisites, E.E. 2abc, Mathematics 1-2-3E.

A study of the fundamentals of direct-current motors and generators. *Two lecture and three laboratory hours a week, fall, winter, and spring quarters. Laboratory fee, $4.00 a quarter.* For electrical engineering students. Value, 10½ quarter-hours. Professors Lear, Bennett, Messrs. Winkler, Stainback.

E.E. 32ab. ELECTRICAL ENGINEERING.

A course designed especially for non-electrical students. The first quarter is devoted to the fundamentals of electricity; the second to machine operation. *Two lecture hours a week, fall and winter quarters.* Value, 4 quarter-hours. Mr. Winkler.

E.E. 52a (60abcs). FUNDAMENTALS OF ELECTRICAL ENGINEERING. Prerequisites, Mathematics 24E, 25E, 26E; Electrical Engineering 32ab.

A study of generation, transmission, control, and utilization of electrical energy. This course is designed to meet the needs of chemical, civil, and mechanical engineering students. *Three lecture hours a week, first six weeks of summer quarter for Coöperative Sections I and II.* Value, 1½ quarter-hours. Professor Lear.

E.E. 52bc. FUNDAMENTALS OF ELECTRICAL ENGINEERING.

Continuation of E.E. 52a. *Three lecture and three laboratory hours a week, fall and spring quarters, for Section I; winter and summer quarters for Section II. Laboratory fee, $5.00 a quarter.* Value, 9 quarter-hours. Mr. Winkler.

E.E. 57a. JUNIOR PROBLEM COURSE.
A special course in problems leading to the design of electrical machinery. *Two hours a week, winter and spring quarters.* Credit, 2 quarter-hours. Professor Lear.

E.E. 62a (63abcs, 73abcs). ELECTRICAL MACHINERY. Prerequisites E.E. 22abc, Mathematics 24E, 25E, 26E.
A thorough study of direct-current machines, from the standpoint of the theory of design, and the economics of manufacture. *Three lecture and three laboratory hours a week, summer quarter, for Coöperative Sections I and II. Laboratory fee, $5.00 a quarter.* Value, 4½ quarter-hours. Professor Lear, Mr. Winkler.

E.E. 62bc. ELECTRICAL MACHINERY.
A continuation of E.E.62a with special emphasis on the use of complex quantities. *Three lecture and three laboratory hours a week, fall and spring quarters for Section I; winter and summer quarters, for Section II. Laboratory fee, $5.00 a quarter.* Value, 9 quarter-hours. Professors Lear, Bennett, Mr. Winkler.

E.E. 67a (86a). INDUSTRIAL APPLICATIONS. Prerequisite, E.E. 62abc.
Selection, arrangement, and control of central station equipment; application and control of d.c. and a.c. motors for textile mills, steel mills, machine shops, etc.; industrial heating; electric furnaces; electric welding. *Three lecture hours a week, fall quarter.* Value, 3 quarter-hours. Mr. Stainback.

E.E. 77a (86b). ILLUMINATING ENGINEERING. Prerequisite, E. E. 62abc.
A study of the physical, physiological, and psychological principles of light and illumination; comparison of light sources; photometry; design of illumination systems for various commercial purposes. *Three lecture hours a week, winter quarter.* Value, 3 quarter-hours. Mr. Stainback.

E.E. 87a (86c). ELECTRIC RAILWAY ENGINEERING. Senior elective.
Design of electric railway systems; train resistance; speed-time curves; power requirements; motor equipment and control; distribution systems; main-line electrification. *Three lecture hours a week, spring quarter.* Value, 3 quarter-hours. Mr. Stainback.

E.E. 97abc (75abc). ELECTRICAL APPLICATIONS LABORATORY.
One laboratory experiment and report a week, accompanying the courses in special fields; a considerable portion of the time will be spent in the standardization laboratory in calibration tests on direct-current and alternating-current measurements instruments, magnetic measurements, iron loss, and instrument transformers. *Four laboratory hours a week, fall, winter, and spring quarters. Laboratory fee, $3.00 a quarter.* Value 6 quarter-hours. Mr. Stainback.

Courses for Graduates and Advanced Undergraduates

E.E. 102a (85a). ELECTRIC CIRCUITS. Prerequisites, E.E. 62abc and Mathematics 24E, 25E, 26E.
A mathematical study of the fundamental phenomena in the electric, magnetic, dielectric, and thermal circuits, emphasizing the circuital relations common to all. Considerable attention will be devoted to the application of complex quantities to alternating-current circuits. *Three lecture hours a week, fall quarter.* Value, 3 quarter-hours. Professor Bailey.

E.E. 112a (85b). ELECTRICAL MEASUREMENTS. Prerequisite, E. E. 102a.
Theory, calibration, and use of instruments for the measurement of current, potential difference, power, and energy; bridge methods of measuring resistance.

inductance, and capacitance; instrument transformers; magnetic measurements; dielectric tests; cable testing. *Three lecture hours a week, winter quarter.* Value, 3 quarter-hours. Professor Bailey.

E.E. 122a (85c). COMMUNICATION ENGINEERING. Senior elective. Prerequisite, E.E. 102a.

A study of the fundamentals involved in the transmission of intelligence by telegraph, telephone, and radio; local and central office equipment for manual and machine switching systems; elements of telegraph and telephone transmission; laws of oscillatory circuits; radio transmission; study of the electron tube as detector, amplifier, and oscillator. *Three lecture hours a week, spring quarter.* Value, 3 quarter-hours. Professor Bennett.

E.E. 162 abc (64abc, 74abc). ALTERNATING-CURRENT MACHINERY AND POWER TRANSMISSION. Prerequisites, E.E. 62abc, Mathematics 24E, 25E, 26E.

A thorough study of the theory of the alternator, transformer, synchronous motor, synchronous converter, induction motor, and generator, and the various types of single-phase commutator motors, and the electrical principles involved in long distance power transmission. *Three lecture and six laboratory hours a week. Laboratory fee, $7.00 a quarter.* Value, 18 quarter-hours. Professor Lear, Mr. Winkler.

E.E. 172abc (84abc). DYNAMO DESIGN. Prerequisite, E.E. 62abc.

Electrical, mechanical, and economic questions involved in the design of electrical machinery; the effect of the design constants on the proportions and operation of machines. Each student will be required to make complete calculations for a d.c. generator or motor, a transformer, and an alternator. *Two lecture and four laboratory hours a week, fall, winter, and spring quarters.* Value, 12 quarter-hours. Professor Lear, Mr. Winkler.

Courses Primarily for Graduates

262a (164a). ELECTRIC TRANSIENTS.

The mathematical theory of the phenomena of the transient state met with in the operation of electric circuits and machines; training in the technique of the oscillograph by the taking of a large number of oscillograms of characteristic transient phenomena. *Laboratory fee, $10.00.* Value, 3 quarter-hours. Professor Lear.

272a (164b). HYPERBOLIC FUNCTIONS APPLIED TO TRANSMISSION PROBLEMS.

Use of hyperbolic functions of complex variables in the calculation of long distance transmission systems. Power relations in long lines; design of artificial lines. Value, 3 quarter-hours. Professor Lear.

282a (164c). DESIGN OF TRANSMISSION SYSTEMS.

Economic principles involved in the preliminary layout; insulation and lightning protection; sag of conductors; mechanical design of poles and towers. Value, 3 quarter-hours. Professor Lear.

382abc (184abc). ELECTRICAL ENGINEERING RESEARCH AND DESIGN.

The solution of one or more definite problems in some particular field of electrical engineering. The work of this course will be outlined, as far as possible, to suit the needs of the individual student, and will consist of original investigations, designs, or the economic study of some existing electric power plant. Value, 27 quarter-hours. Professor Lear.

MECHANICAL ENGINEERING

Courses for Undergraduates

M.E. 48abc (2a). MECHANISM. Prerequisites, General Engineering 1abc, Mathematics 1-2-3E. Required of mechanical and electrical engineering sophomores.

The relative motions, velocities, and accelerations of machine parts, including a study of linkages, cams, gears, belts, gear trains, and other mechanisms. *One lecture and three laboratory hours a week, fall, winter, and spring quarters.* Value, 7½ quarter-hours. Professors Smith, Michel, Mr. Watson.

M. E. 53a (90abc). STEAM AND GAS MACHINERY. Prerequisites, Mathematics 24-25-26E, Physics 21-22-23E. Required of civil and chemical engineering juniors, Coöperative Sections I and II.

A course in the fundamentals of steam and gas heat-power machinery, designed especially for the needs of students in civil and chemical engineering; includes a study of the principles governing the operation of steam engines, steam turbines, gas engines, boilers, and boiler auxiliaries. *Three lecture hours a week, first term of summer quarter.* Value, 1½ quarter-hours. Professor Hoefer.

M.E. 53bc. STEAM AND GAS MACHINERY. Prerequisite, Mechanical Engineering 53a. Required of civil and chemical engineering juniors.

A continuation of Mechanical Engineering 53a. *Three lecture and three laboratory hours a week, fall and spring quarters for section I; winter and summer quarters for section II. Laboratory fee, $5.00 a quarter.* Value, 9 quarter-hours. Professors Hoefer, Michel, Mr. Pittana.

M.E. 63abc (93abc). THERMODYNAMICS AND HEAT ENGINES. Prerequisites, Mathematics 24-25-26E, Physics 21-22-23E. Required of mechanical and electrical engineering juniors.

A study of the laws governing the transformation of heat into mechanical energy; properties of gases and vapors; gas and vapor cycles; power, efficiency, and performance of heat engines; study of steam engines, steam turbines, gas engines, compressed air, and refrigeration. *Three lecture and three laboratory hours a week, summer quarter for Coöperative Sections I and II; fall and spring quarters for Section I; winter and summer quarters for Section II. Laboratory fee, $5.00 a quarter.* Value, 13½ quarter-hours. Professors Hoefer, Michel, Mr. Pittana.

M.E. 66a (92c). GENERAL AERONAUTICS. Prerequisites, Physics 21-22-23E or equivalent. Required of mechanical engineering juniors.

A study of simple aerodynamics, airplane engines, aircraft instruments, navigation, and commercial aviation. Textbook: *Simple Aerodynamics* by Monteith and Carter. *Two lecture hours a week, winter quarter for Coöperative Section II; spring quarter for Section I.* Value, 2 quarter-hours. Professor Bailey.

M.E. 68a (91s). ELEMENTARY MACHINE DESIGN. Prerequisites, General Engineering 26abc, Mechanical Engineering 48abc, Mathematics 24-25-26E. Required of mechanical and electrical engineering juniors, Coöperative Sections I and II.

The study and design of the elementary parts of machines, including riveted joints, screws, keys, shafts, gearing, belting, and power transmissions, using the principles of mechanics and accepted empirical methods as a basis. *Three lecture and six laboratory hours a week during first term, six lecture and twelve laboratory hours a week during second term of summer quarter.* Value, 9 quarter-hours. Professor Bailey.

M.E. 73a (99abc). STEAM ENGINES AND TURBINES. Prerequisite, Mechanical Engineering 63abc. Option for mechanical engineering seniors.

A continuation of thermodynamics and heat engines of the junior year, with further study in the field of steam engineering. It includes the laws governing the flow of fluids and applications to orifices and nozzles; advanced discussion of the thermodynamic processes and cycles of vapors; a study of reheating and regenerative cycles as applied to steam turbine practice; a study of the simple and compound reciprocating steam engine. *Five lecture and three laboratory hours a week, fall quarter. Laboratory fee, $5.00.* Value, 6½ quarter-hours. Professor Hoefer.

M.E. 78abc (99abc). INTERNAL COMBUSTION ENGINES. Prerequisite, Mechanical Engineering 63abc. Required of mechanical engineering seniors.

A continuation of thermodynamics and heat engines of the junior year, with further study in the field of internal combustion engines. It includes a more advanced discussion of the thermodynamic processes of gases and of gas cycles, involving variable specific heats and "Real Mixture Standards"; fuels and their combustion, carburetors and methods of fuel injection; performance of internal combustion engines. *Three lecture hours a week, fall and winter quarters; two lecture and three laboratory hours a week, spring quarter. Laboratory fee, $5.00.* Value, 9½ quarter-hours. Professor Bailey.

M.E. 83a (94ab). STEAM BOILERS AND ACCESSORIES. Prerequisite, Mechanical Engineering 73a. Option for mechanical engineering seniors.

A study of fuels and combustion, boilers and boiler accessories, gas producers, feed-water heaters, economizers, and condensers. *Five lecture and four laboratory hours a week, winter quarter. Laboratory fee, $5.00.* Value, 7 quarter-hours. Professor Hoefer.

M.E. 88abc (91abc). MACHINE DESIGN. Prerequisites, General Engineering 56a, Mechanical Engineering 68a. Required of mechanical engineering seniors.

A continuation of Mechanical Engineering 68a and the strength of materials given in General Engineering 56a. Stress analysis and design of basic machine parts, and the dynamics of machinery and engines. *Two lecture and eight laboratory hours a week, fall, winter, and spring quarters.* Value, 18 quarter-hours. Professor Bailey.

M.E. 93a (95c). STEAM AND GAS ENGINEERING DESIGN. Prerequisite, Mechanical Engineering 83a. Option for mechanical engineering seniors.

Calculations used in the determination of sizes and the more important details of power plant apparatus, such as steam engines and turbines, gas engines, air compressors, boilers, etc.; problems in heating and ventilation. *Three lecture and eight laboratory hours a week, spring quarter.* Value, 7 quarter-hours. Professor Hoefer.

Courses for Graduates and Advanced Undergraduates

M. E. 166a (96a). AERODYNAMICS. Prerequisites, General Engineering 26abc, Civil Engineering 65a, Mechanical Engineering 66a. Option for mechanical engineering seniors.

This course covers fluid mechanics, similitude, functions and characteristics of air foils, theory and calculation of airplane performance, stability, control and maneuverability. Textbook: *Airplane Design* by Warner, *Applied Aerodynamics* by Barstow, and the reports of the National Advisory Committee for Aeronautics. *Five lecture and three laboratory hours a week, fall quarter. Laboratory fee, $5.00.* Value, 6½ quarter-hours. Professor Bailey.

M.E. 176ab (97bc). AIRPLANE DESIGN. Prerequisites, General Engineering 56a, Mechanical Engineering 166a. Option for mechanical engineering seniors.

This course includes the calculation of airplane loadings, materials of construction, stress analysis, Department of Commerce requirements, design methods, weight control, and structural tests. Textbook: *Airplane Stress Analysis* by Klemin, *Airplane Design* by Warner, and references in structural analysis texts and current periodicals. *Two lecture and three laboratory hours a week, winter and spring quarters.* Value, 7 quarter-hours. Professor Bailey.

M.E. 186ab (98bc). AIRPLANE ENGINES. Prerequisite, Mechanical Engineering 166a; corequisite, Mechanical Engineering 78abc. Option for mechanical engineering seniors.

A study of airplane engines and propellers, design principles, performance calculations, and altitude effects; characteristics of existing engines, accessories, and engine testing and construction. Textbook: *The Airplane Engine* by Marks, and references in engine design textbooks, current literature, and manufacturers' specifications. *Two lecture and three laboratory hours a week, winter and spring quarters. Laboratory fee, $5.00.* Value, 7 quarter-hours. Professor Bailey.

Courses Primarily for Graduates

M.E. 283abc (194abc). ADVANCED ENGINEERING THERMODYNAMICS. Prerequisites, Mechanical Engineering 78abc and 83a.

An advanced course in thermodynamics with application to the theory and design of heat-power apparatus, such as steam engines and turbines, internal combustion engines, refrigerating machines, and heating and ventilating systems. Value, 5 quarter-hours a quarter. Professor Hoefer.

M.E. 288abc. ADVANCED MECHANICAL DESIGN. Prerequisite, Mechanical Engineering 88abc.

A mathematical and experimental study of the effects of motion and vibration on the design and performance of machines and structures. Value, 5 quarter-hours a quarter. Professor Bailey.

NON-ENGINEERING SUBJECTS

(The non-engineering courses described below are those required in the various engineering curricula. For additional courses in these and other departments that are open to undergraduate engineering students, or that may be elected as minors by graduate students, see the general catalogue of the University.)

CHEMISTRY

Courses for Undergraduates

1-2. GENERAL DESCRIPTIVE CHEMISTRY.

An introduction to the study of the principal non-metallic and metallic elements and their compounds. Lectures with laboratory work. *Four lecture and four laboratory hours a week, each course every quarter. Laboratory fee, $5.50 a quarter.* Professors Bell, Cameron, Edmister, Crockford, Messrs. Belcher, Byrd, Fleming, Harrill, King, LeConte, Turner.

41. ELEMENTARY QUANTITATIVE ANALYSIS. Prerequisites, Chemistry, 1-2.

Gravimetric Analysis. Laboratory work, lectures, and stoichiometric exercises. *Three lecture and six laboratory hours a week, fall quarter. Laboratory fee, $10.00.* Professor Dobbins, Messrs. Ljung, Gilreath, Sanders, Smith, Byrd.

42. ELEMENTARY QUANTITATIVE ANALYSIS. Prerequisites, Chemistry 1-2.
Volumetric analysis. Laboratory work, lectures, and stoichiometric exercises. *Three lecture and six laboratory hours a week, winter or spring quarter. Laboratory fee, $10.00.* Professor Dobbins, Messrs. Ljung, Gilreath.

51 (7). INORGANIC CHEMISTRY. Prerequisites, Chemistry 1-2.
A detailed study of inorganic chemistry. Required of S.B. Chemistry students. Elective for students in A.B., A.B. in Education, or S.B. Chemical Engineering courses. *Five lectures a week, fall quarter.* Professor Cameron.

61. ORGANIC CHEMISTRY. Prerequisites, Chemistry 1-2.
Aliphatic series. *Three lecture and six laboratory hours a week, fall or winter quarter. Laboratory fee, $10.00 a quarter.* Professors Wheeler, Bost, Messrs. Mattox, King.

62. ORGANIC CHEMISTRY. Prerequisite, Chemistry 61.
Aromatic series. *Three lecture and six laboratory hours a week, winter or spring quarter. Laboratory fee, $10.00 a quarter.* Professors Wheeler, Bost, Mr. Mattox.

66. ORGANIC CHEMISTRY. Prerequisites, Chemistry 61, 62.
Selected reading in organic chemistry from German texts. *Five hours a week, spring quarter.* Professor Wheeler.

81, 82. ELEMENTARY PHYSICAL CHEMISTRY. Prerequisite, Chemistry 42.
Study of the properties of solids, liquids, and gases, and of their relation to chemical constitution. *Three lecture and six laboratory hours a week, winter and spring quarters. Laboratory fee, $7.00 a quarter.* Professors Bell, Crockford, Mr. Ruble.

91 (45). TECHNICAL QUANTITATIVE ANALYSIS. Prerequisites, Chemistry 41, 42.
Water, coal, petroleum products, gas, iron, and steel. *Three lecture and six laboratory hours a week, winter quarter. Laboratory fee, $10.00.* Professor White, Mr. Hughes.

92 (46). TECHNICAL QUANTITATIVE ANALYSIS. Prerequisites, Chemistry 41, 42.
Ore assay, fertilizer, cotton products, and food analysis. *Three lecture and six laboratory hours a week, spring quarter. Laboratory fee, $10.00.* Professor Crockford.

93 (47). OPTICAL METHODS OF ANALYSIS. Prerequisite Chemistry 41.
Microscopic and microchemical methods. *Three lecture and six laboratory hours a week, spring quarter. Laboratory fee, $5.00.* Not offered in 1931-32.

Courses for Graduates and Advanced Undergraduates

121-122-123 (21-22-23). RESEARCH. Prerequisites, Chemistry 61, 62, 81, 82.
Twelve laboratory hours a week, fall, winter, and spring quarters. Laboratory fee, $10.00 a quarter Professors Bell, Wheeler, Cameron, Dobbins, Edmister, Crockford, White, Bost.

163 (63). IDENTIFICATION OF PURE ORGANIC COMPOUNDS. Prerequisites, Chemistry, 61, 62.
Lectures and laboratory. *Three lecture and six laboratory hours a week, fall quarter. Laboratory fee, $10.00.* Professor Bost.

164 (64). CHEMISTRY OF DYESTUFFS. Prerequisites, Chemistry 61, 62.
Lectures and laboratory. (Given in 1931-1932 and in alternate years.) *Three lecture and four laboratory hours a week, winter quarter. Laboratory fee, $10.00.* Professors Wheeler, Bost.

165 (65). ADVANCED TOPICS IN ORGANIC CHEMISTRY. Prerequisites, Chemistry 61, 62.
Lectures and laboratory. (Given in 1930-31 and in alternate years.) *Three lecture and four laboratory hours a week, winter quarter. Laboratory fee, $10.00.* Professors Wheeler, Bost.

183 (83). ADVANCED PHYSICAL CHEMISTRY. Prerequisites, Chemistry 81, 82.
Lectures and textbooks. *Five hours a week, fall quarter.* Professor Crockford.

184 (84). ELECTROCHEMISTRY. Prerequisites, Chemistry 81, 82.
Lectures and textbooks. *Five hours a week, winter quarter.* Professor Crockford.

185 (85). ELECTROCHEMISTRY. Prerequisite, Chemistry 184.
Laboratory course in electrochemistry to follow the lecture course, Chemistry 184. *Six laboratory hours a week, spring quarter. Laboratory fee, $7.00.* Professor Crockford.

191, 192 (11, 12). CHEMICAL TECHNOLOGY. Prerequisites, Chemistry 61, 62, 91, 92.
The methods and economics of the chemical industries; lectures and laboratory work. *Three lecture and six laboratory hours a week, fall and winter quarters. Laboratory fee, $10.00 a quarter.* Professor Cameron, Mr. Hughes.

Courses Primarily for Graduates

291, 292, 293 (112abc). ADVANCED TECHNICAL CHEMISTRY. Prerequisites, Chemistry 191, 192.
Seminar course: readings and discussions of recent advances in technical chemistry. *One lecture and four library hours a week, fall, winter, and spring quarters.* Professor White.

391, 392, 393 (111abc). RESEARCH IN INDUSTRIAL CHEMISTRY.
The statements made in regard to courses 341, 342, 343 apply also to this course. *One lecture and nine laboratory hours a week, fall, winter, and spring quarters. Laboratory fee, $10.00 a quarter.* Professor White.

ECONOMICS AND COMMERCE

Economics

31-32 (1-2). GENERAL ECONOMICS. Not open to freshmen.
This course is planned to give a general understanding of the organization of our economic life and the fundamental principles underlying it. An analysis is made of production, distribution, and consumption; of the elements which determine value and price, with a brief introduction to money, banking and credit, monopoly, business combinations, transportation, labor problems, and economic reform. *Five hours a week, fall and winter, or winter and spring, or spring and summer quarters.* Professors Carroll, Woosley, Spruill, Lear, Wolf, Ferger, Evans, Mr. Winslow.

Commerce

51E-52E-53E (10-11-12E). BUSINESS ADMINISTRATION FOR STUDENTS IN ENGINEERING. Open to students in the School of Engineering only. Prerequisites, Economics 31-32.

The elements of business organization with emphasis on the corporation, its nature, its promotion, its financing, and its operation. Internal organization with special reference to methods of control, managerial accounting, cost analysis, financing of current operations, valuation and methods of appraisal, depreciation, sinking funds, and the interpretation of financial statements. The economics of locating and managing industrial plants, the handling of the labor factor through specialized personnel administration, and the relations existing between consumers and producers. *Three hours a week, fall, winter, and spring quarters.* Professor Schwenning.

ENGLISH

9abc (9ab). COMPOSITION FOR ENGINEERS: INTRODUCTORY COURSE. Open only to students in the School of Engineering.

Two hours a week and weekly conferences, fall, winter, and spring quarters. Messrs. Bailey (Chairman), Stroup.

29ab. LITERATURE FOR ENGINEERS. Open only to students in the School of Engineering.

Two hours a week, fall and winter quarters. Professor Howell.

59 (11abc). ADVANCED TECHNICAL COMPOSITION. Open only to students in the School of Engineering.

Five hours a week, winter or spring quarter. Professor Howell.

60abc (10). PUBLIC SPEAKING FOR ENGINEERS. Open only to students in the School of Engineering.

Two hours a week, fall, winter, and spring quarters. Professors McKie, Olsen.

GEOLOGY

11-12 (1-2). INTRODUCTION TO GEOLOGY.

Lectures with laboratory and field work; laboratory work in the first quarter on common minerals and rocks, and map interpretation; in the second quarter on geological folios and the more common fossils. The first quarter deals with physical geology, with physiographic processes and their results; the second quarter is a study of the outlines of historical geology. Geology 11 is offered during the summer on the transcontinental tour also. *Four lecture and four laboratory hours a week, fall and winter or winter and spring quarters. Geology 11 repeated in spring quarter. Laboratory fee, $3.00 a quarter.* Professors Cobb, Prouty, Swartz, MacCarthy, and assistants.

43-44 (3-4). MINERALOGY. Prerequisites, Geology 11-12, Chemistry 1-2.

Crystallography, physical and chemical properties of minerals, blow-pipe analysis; lectures, laboratory work, and field work. *Two lecture and six laboratory hours a week, fall and winter quarters. Laboratory fee, $5.00 a quarter.* Professor MacCarthy.

77-78 (18, 19, 20). ENGINEERING GEOLOGY.

The course consists in a general study of physical geology with a more intensive study of materials and structures of the earth in reference to engineering problems. *Three lecture periods and four laboratory hours a week, fall and winter quarters. Laboratory fee, $3.50 a quarter.* Credit 5 quarter-hours a quarter. Professor Prouty.

HISTORY

85. ECONOMIC HISTORY OF THE NINETEENTH CENTURY. Open only to students in the School of Engineering.

A course dealing with the economic materials, institutions, and influences in the history of the modern world, with especial emphasis on European nations and the United States. *Five hours a week, fall or summer quarter.* Professor Crittenden.

MATHEMATICS

1E. PLANE TRIGONOMETRY AND PRACTICAL MEASUREMENTS. Required of freshmen in engineering courses.

Solution of right and oblique triangles by logarithms, with problems drawn from engineering practice. Selected theorems from solid geometry with special emphasis on the sphere. *Six hours a week, fall quarter.* Professors Winsor, Linker, Hill, Parker, Mr. Cameron.

2E. SPHERICAL TRIGONOMETRY AND ALGEBRA. Required of freshmen in engineering courses.

Solution of right and oblique spherical triangles. A study of the elementary functions from the point of view of their graphical representation and differentiation. *Six hours a week, winter quarter.* Professors Winsor, Linker, Hill, Parker, Mr. Cameron.

3E. ANALYTIC GEOMETRY. Required of freshmen in engineering courses.

A treatment of the straight line, circle, conic sections, special plane curves, transformation of coördinates. *Six hours a week, spring quarter.* Professors Winsor, Linker, Hill, Parker, Mr. Cameron.

24E (4E). CALCULUS I FOR ENGINEERING STUDENTS. Required of sophomores in engineering courses. Prerequisite, Mathematics 13 or 3E.

A study of the derivative and its applications to geometry and mechanics, expansion of functions, partial differentiation. *Five hours a week, fall quarter.* Professors Winsor, Linker, Hill.

25E (5E). CALCULUS II FOR ENGINEERING STUDENTS. Required of sophomores in engineering courses. Prerequisite, Mathematics 24E.

The definite integral and its applications. *Five hours a week, winter quarter.* Professors Winsor, Linker, Hill.

26E (6E). CALCULUS III FOR ENGINEERING STUDENTS. Required of sophomores in engineering courses. Prerequisite, Mathematics 25E.

Engineering problems involving the calculus, together with an elementary treatment of the differential equations. *Five hours a week, spring quarter.* Professors Winsor, Linker, Hill.

PHYSICS

21-22-23E (1-2-3E). PHYSICS FOR ENGINEERING STUDENTS. Required of engineering sophomores. Prerequisites, Mathematics 1-2-3E or equivalent.

This is a course given with special reference to the needs of students of engineering, both in the lecture work and in the laboratory, while a great deal of problem work is given on subjects dealing with engineering. *Three lecture and two laboratory hours a week, fall, winter, and spring quarters. Laboratory fee, $2.50 a quarter.* Professor Fussler, Mr. Shearin.